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A comparison of high-end video teleconference alternatives for the Department of Defense

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A COMPARISON OF HIGH-END VIDEO TELECONFERENCE ALTERNATIVES FOR THE DEPARTMENT OF DEFENSE

by

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The thesis provides a basic introduction to VTC, including an explanation of VTC terminology and a discussion of VTC standards. The thesis looks at VTC within DOD, including some history, current applications and directives in effect. Several prominent DOD VTC networks are described.

This research finds that each VTC method examined contains advantages that support its continued existence in the near-term. This thesis concludes that the variety of DOD applications justifies the divergent methods for employing VTC, until a DOD-wide standard communications infrastructure is in place.

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I. INTRODUCTION

A. BACKGROUND

Video teleconference (VTC) technology is advancing rapidly and the Department of Defense (DOD) has been a key contributor to its growth. This thesis describes and contrasts video teleconferencing alternatives within DOD.

In pioneering VTC development along various and often dissimilar applications, DOD is demonstrating the versatility and usefulness of VTC for providing cost-effective solutions to meet diverse requirements. However, in its role as a leading-edge contributor to the technology, DOD has developed distinct (and occasionally competing) VTC strategies. While this situation mirrors the growth of the technology in the private sector, it nonetheless has resulted in VTC systems that are unable to, or limited in their ability to interact with other VTC networks.

The problem lies in the fact that there are various methods for employing VTC, both in the private sector and in DOD. The diversity stems from a variety of sources. Telecommunications transmission has migrated from the copper wire phone lines to satellites and then back to earth again with the development of optical fiber. The government has mandated FTS2000 use for telecommunications, but numerous

exemptions and exceptions abound, especially within DOD. One-way and two-way video solutions are effectively (and incompatibly) satisfying user requirements. The situation is compounded by the fact that there has been no widely accepted VTC standard until very recently, and even this new VTC standard is still evolving. The simultaneous existence of dissimilar systems was practically inevitable.

B. METHODOLOGY

Except for promotional information provided by vendors and network managers, there is very little written documentation on the current status of VTC technology in DOD. VTC technology is developing so quickly that the prevailing DOD standards are sometimes found in the latest version of a draft directive that is widely circulated. The research for this paper combines recent VTC literature, presentations from conferences and personal observations from individuals intimately familiar with the operations/costs of their particular network.

In general, three types of transmission media are available to support VTC; these are terrestrial, satellite and line-of-sight microwave links. This paper will only address the first two categories of terrestrial and satellite VTC, as these two areas represent virtually all of the DOD VTC applications currently in use. Within DOD, the following

areas are examined regarding their potential for videoconferencing:

- Common-user Networks, including the Defense Commercial Telecommunications Network (DCTN) and NAVNET;
- Satellite Videoconferencing;
- FTS 2000 (Federal Telecommunications Service 2000).

C. SCOPE OF THESIS

1. Costs Disclaimer

The reader is cautioned not to accept the cost comparisons as representing the full cost of video teleconferencing. Cost comparisons represented in this paper exclude (to the extent possible) costs that might vary from one command to the next. Examples of additional costs include, but are not limited to the following: video facility design, development and installation costs; salaries for personnel dedicated to coordinating the equipment and circuits; costs for training and documentation; instructor salaries; costs for additional cabling; costs for additional video options; etc. Each command must determine what its requirements are and what equipment and method of service will best meet the requirement.

VTC costs are constantly changing. Figures provided in this paper will change as new data transmission services are proposed and approved.

2. Desktop Video Teleconferencing

One area that holds potential for significant development in both DOD and the private sector is desktop videoconferencing. This technology is still in its infancy, and the private sector is debating whether it should occupy a separate market category, or be included within the category of multimedia applications [Ref. 1]. Some government agencies that have been recently experimenting with desktop videoconferencing, opined that the current state of technology did not adequately meet their requirements [Ref. 2: p. 25].

Fort Huachuca, Arizona, is one of several areas within DOD that is pioneering desktop videoconferencing solutions specifically relevant to DOD. However, because the technology is still evolving (arguably more so than high-end videoconferencing applications), desktop videoconferencing is considered a separate application of videoconferencing and beyond the scope of this paper.

D. ORGANIZATION

This paper begins by providing some general videoconferencing background in Chapter II, followed by DOD-specific VTC applications and guidelines in Chapter III. Chapter IV and Chapter V discuss DOD common-user networks DCTN and NAVNET. Chapter VI discusses satellite VTC, including a comparison of one-way and two-way VTC methods. Chapter VII

deals with different VTC alternatives that are available using FTS2000 service. The final chapter provides a comparative analysis of the alternatives and provides a perspective on future videoconferencing trends, both in DOD and the private sector.

II. VIDEO TELECONFERENCING BACKGROUND

This chapter will provide some background into video teleconferencing with a specific slant toward video teleconferencing within DOD. This chapter will begin with a brief definition of terminology, describe the role of international standards groups, and then outline the development of video teleconferencing, including components and techniques needed to make video teleconferencing occur. This chapter discusses the evolution of video teleconferencing and regulations that apply to video teleconferencing use within DOD. The final portion of the chapter briefly describes some video teleconferencing systems in DOD that are not mentioned elsewhere in the paper.

A. VIDEO TELECONFERENCING TERMINOLOGY

1. Video Teleconferencing Vs. Teletraining

A variety of different terms (and some acronyms) have been used to describe video-related interaction. Some of these include video teleconferencing, videoconferencing, video conference, video seminar, video teleseminar, video training, teletraining, video teletraining, distance learning, distance education, satellite education, business video, etc. Depending on the context of the user, any of the previous terms might or might not apply to areas of this paper. For

consistency, this paper will use "video teleconferencing" or the video teleconferencing acronym, "VTC." A draft Military Standard on the "Interoperability and Performance Standard for Video Teleconferencing" (MIL-STD-188-331), that was released for private industry comment, provides the following definition of video teleconferencing:

> Two-way electronic form of communications that permits two or more people in different locations to engage in face-to-face audio and visual communication. Meetings, seminars, and conferences are conducted as if all of the participants are in the same room. [Ref. 3: p. 23]

By comparison, teletraining (or "distance learning") is defined as "the use of teleconferencing point-to-point or multi-point to provide interactive remote site training" [Ref. 3]. Note that teletraining does not necessarily require two-way video; the interaction might be audio-only, or one-way video with two-way audio. A significant number of DOD teletraining applications include at least one-way video to accompany the audio.

2. The Role of ITU-TSS (or CCITT)

The International Telecommunications Union (ITU) is one of several United Nations organizations responsible for reviewing and establishing international standards. The ITU has recently been organized into a new structure that consists of a Standardization Sector, a Radiocommunication Sector and a Development Sector. Figure 1 summarizes the ITU technical structure.

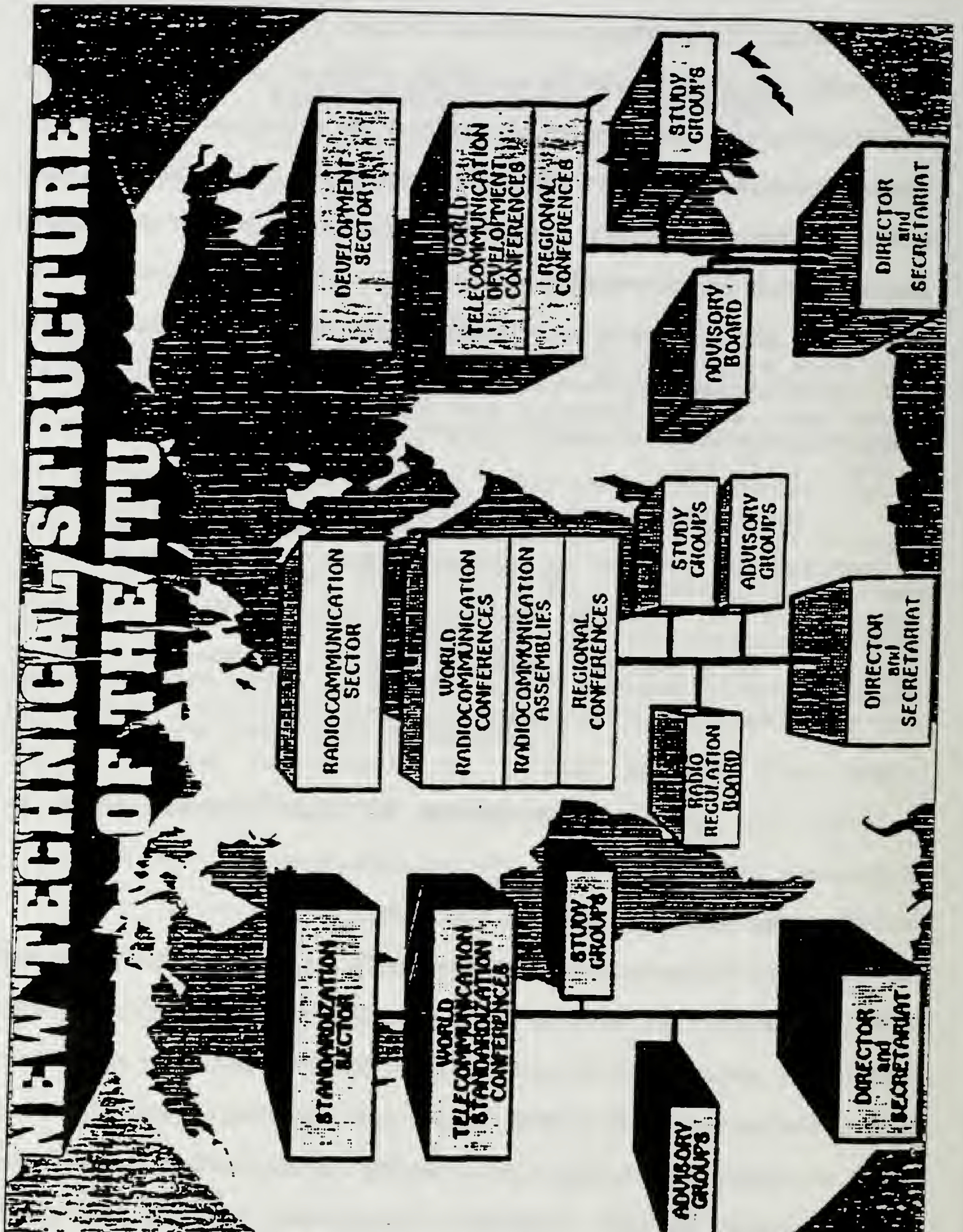

Figure 1 ITU Technical Structure [Ref. 4]

The ITU Telecommunications Standardization Sector (ITU-TSS) is specifically responsible for establishing international telecommunications standards.

The International Consultive Committee for Telephone and Telegraph (CCITT) is a subsidiary of the ITU. Under the new ITU organization, work formerly performed by the CCITT is now handled by the Telecommunication Standardization Sector (TSS or ITU-TSS). Essentially, CCITT is now ITU-TSS; these terms appear interchangeably in contemporary literature.

3. Role of H.320

CCITT recommendation H.320 ("Narrow-band Visual Telephone Systems and Terminal Equipment, 1990") refers to a family of standards that governs video teleconferencing and videophone systems that use codecs at transmission speeds between 56 Kbps and 1,920 Kbps. H.320 prescribes the technical requirements for terminals, multiplexers, signalling and system control, compression algorithms and audio transmission. H.320 became a mandatory standard for the Federal Government in June 1993 (six months after Federal Information Processing Standard (FIPS) 178 was approved).[1] The H.320 standards applied to an audiovisual terminal are summarized in Figure 2.

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[1] Additional detail on standards is supplied in the section on FIPS 178.

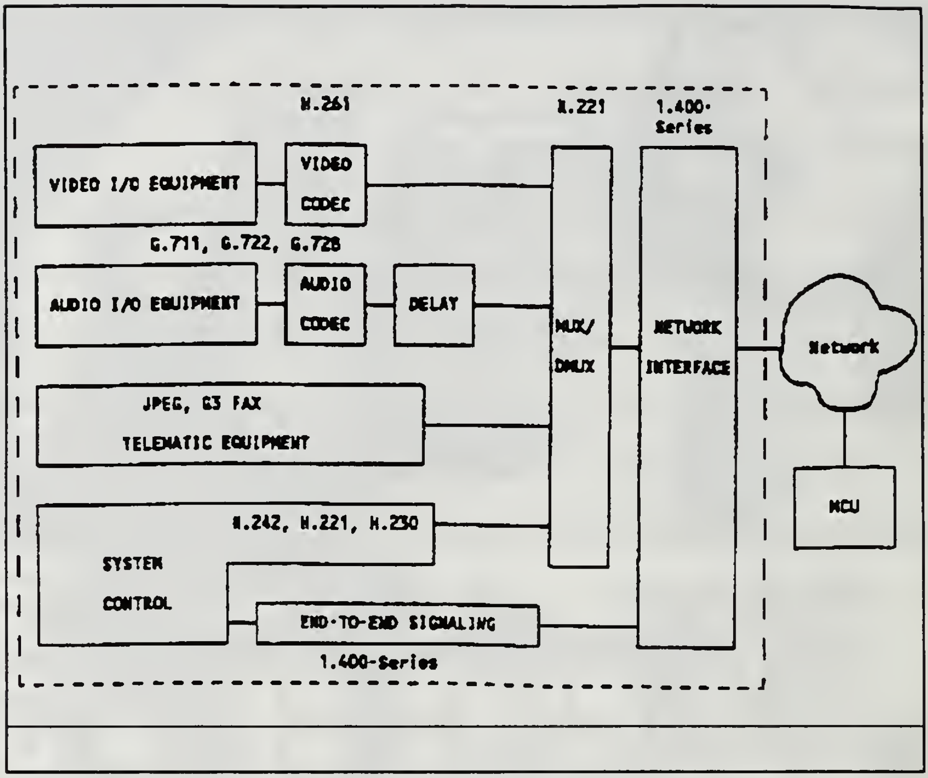

Figure 2 H.320 Audiovisual Terminal [Ref. 4]

H.320 provides for different levels of compliance with respect to compression picture resolution, motion compensation, audio quality and frame speed. Table I summarizes some differences between levels of H.320 compliance.

Table I LEVELS OF H.320 COMPLIANCE

	Level 1 (Minimum)	Level 2 (Medium)	Level 3 (High)
Frame Format (pixels)	QCIF (176 x 144)	CIF (352 x 288)	CIF (352 x 288)
Frame Speed (frames/sec)	5	up to 15	up to 30
Data Rate	56 / 64 Kbps	up to 384 Kbps	up to 1.544 Mbps
Motion Compensation	No	Limited (6x6 = 36)	Full motion (30x30 = 900)
Pre and post processing on both encoder and decoder	Not applicable	Not applicable	Pre and post processing on both encoder and decoder

[Ref. 5]

CIF and QCIF are described in more detail in Appendix B.

The H.320 standard provides for three levels of audio. These are summarized in Table II.

Table II H.320 AUDIO STANDARDS

CCITT Recommendation	Bandwidth	Bit Rate	Coding Algorithm
G.711	3 KHz	64 Kbps	PCM
G.722	7 KHz	48 Kbps 56 Kbps 64 Kbps	Dual Band, DPCM
G.728	3 KHz	16 Kbps	Low Delay Code Excited Linear Prediction
AV.253	7 KHz	32 Kbps	

[Ref. 4]

The conclusion from this is that different vendors who advertise that they are H.320 -compliant might have noticeably different levels of quality.

B. VTC HISTORY AND BACKGROUND

The AT&T research subsidiary, Bell Laboratories, pioneered most of the VTC work between 1924-1964. Video teleconferencing first appeared as early as 1926, when the President of AT&T, Walter S. Gifford, used a VTC to speak with the Secretary of Commerce, Herbert Hoover. [Ref. 6]

While broadcast television became a major video breakthrough when it was introduced in 1940, the next significant video teleconference demonstration did not occur until nearly a quarter century later when AT&T's motion picture telephone was introduced at the 1964 New York World's

picture telephone was introduced at the 1964 New York World's Fair. Although not practical for that era (at almost $1,000 per minute for the analog transmission), this event planted the seed in many minds of what might be possible someday. [Ref. 7]

Since video signals contain frequencies that were beyond the capabilities of telephone networks in the early '60s, the only alternative to provide video teleconferencing was using satellite communications. However, full-bandwidth satellite transmissions for video teleconferencing as late as 1983, still cost over $1 million per year [Ref. 8].

With the 70's, came new advances in computing power and improved methods for converting analog signals into digital representation. The advantages of signal quality and analysis resulted in a transition by telephone service providers to begin using digital transmission methods along with the existing analog processing. [Ref. 9]

1. Video Compression

The National Television Systems Committee (NTSC) standard picture frame consists of 780 horizontal picture elements (pixels) and 480 active vertical lines.[2] If 8 bits are used to represent each pixel, then sending 30 picture frames per second requires a transmission speed of

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[2] NTSC is the North America standard for transmitting moving pictures.

around 90 Mbps. [Ref. 10][3] Even with digital signal processing, T-1 (1.54 Mbps) lines could not support full-motion video transmission (90 Mbps). The solution was video compression. Compression techniques take advantage of redundancies in data, and in limitations of the human eye [Ref. 11].

A substantial portion of the analog video signal consists of mostly redundant timing and synchronization information. Video compression methods were able to compress the redundant portions of the analog signal to achieve a 45 Mbps transmission rate (2:1 compression ratio) without compromising on picture quality. [Ref. 9]

Other compression methods take advantage of the similarities of information in the same frame (*spatial* redundancy) and in similarities between adjacent frames in a group of moving pictures (*temporal* redundancy). Each picture to be transmitted is composed of individual elements or pixels.[4] *Spatial* redundancy relies on a small number of bits to describe areas (of pixels) in a picture that are the same color, thereby eliminating the need to individually code each pixel for transmission. To capitalize on *temporal* redundancy,

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[3] (8 bits/pixel x 780 pixels/line x 480 lines/frame x 30 frames/second = 89,856,000 bits/second)

[4] Additional information on pixels and other video transmission concepts is provided in Appendix A.

only the pixels that have changed from one frame to the next are transmitted.

There are also compression advantages based on limitations of the human eye. The NTSC frame rate for transmitting moving pictures is 30 frames per second. Most motion pictures take advantage of the fact that the human eye can only discern movement at a rate of about 24 frames per second.[5] Frame rates between 15 and 25 frames per second are still considered "smooth" motion. By this analysis, a compression ratio of 2:1 has been achieved with "smooth" motion, simply by transmitting 15 frames per second instead of 30 frames per second, exploiting limitations of the human eye. [Ref. 9]

"Lossy" algorithms, in which the reconstructed information is not identical to the original signal, take advantage of limitations in vision. Since the eye is more receptive to brightness (luminance) than it is to color (chrominance), bit representations of luminance will both contain more bits and be sampled more frequently than the color components. [Ref. 11]

2. Video Codecs

Several compression techniques have been discussed. The device that performs the compression is the **co**der/**dec**oder

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[5] A frame rate of 25 frames per second is considered "VHS" quality; 28 frames per second is approximately "Super-VHS" quality.

device (codec). It is the heart and soul of the two-way video teleconferencing systems.[6] The primary codec functions are twofold:

- to convert (code) analog signals into digital form prior to transmission and then to reverse the process (decode--digital to analog) for all received signals, and
- to compress data prior to transmission and to decompress data after it has been received. [Ref. 12]

In 1982, Compression Labs, Inc. developed the first 1.5 Mbps codec [Ref. 13]. GPT Video Systems introduced the first commercially available codec that conformed to the H.261 standard in 1990 [Ref. 14].

3. Role of H.261 in Video Teleconferencing

H.261 (sometimes referred to as the px64 standard) is an interoperability standard that pertains to communication between codecs; specifically, it applies to the compression algorithm. H.261 guarantees that different codecs will be able to communicate if they encode and decode video signals according to the standard (H.261) motion video compression algorithms. [Ref. 15: p. 3]

H.261 prescribes both mandatory and optional formats that provide varying degrees of quality and resolution. These

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[6] "Two-way" is specifically mentioned here to differentiate this system from the one-way distance learning application. The ordinary one-way distance learning configuration uses an encode only device at the uplink site with decode only devices at the receive sites. This will be discussed in greater detail in Chapter IV.

formats, the Common Intermediate Format (CIF) and the Quarter CIF (QCIF) are discussed in greater detail in a separate section.

Most codec manufacturers include both an H.261 standard compression format as well as a proprietary compression algorithm. The proprietary algorithm is generally noticeably better than the H.261 standard. Two (or more) codecs from the same manufacturer will always provide improved performance when operating the manufacturers proprietary mode. When two dissimilar codecs are connected in a video teleconference, they must communicate using the H.261 standard.[7]

4. Discrete Cosign Transform Coding

Codecs achieved a major breakthrough in video compression techniques by employing Discrete Cosign Transform (DCT) coding. DCT is the technology used to exploit temporal and spatial redundancy.

> DCT transforms a block of pixel intensities into a block of frequency transform coefficients. The transform is applied in turn to new blocks until the entire image has been transformed. At the decoder in the receiver, the inverse transformation is applied to recover the original image. [Ref. 16]

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[7] This is assuming the dissimilar modems both have an H.261 standard mode. A widespread DOD example where this is not the case is the older *Rembrandt I* model by Compression Labs, Inc. The *Rembrandt I* is not compliant with the H.261 standard and can only communicate with other *Rembrandt I* models.

It was only by using DCT coding that codecs were finally able to achieve compression ratios needed to transmit data over a T-1 line.

DCT is required for all H.261 codecs; it is also the required compression standard for transmitting still pictures (JPEG), motion video (MPEG), and high definition television [Ref. 17].[8]

5. Picture Resolution and Quality

There are three primary video transmission formats:

- NTSC -- National Television System Committee (North America, Japan)
- SECAM -- Sequential color and memory (Europe), and
- PAL -- Phase alternation line (Europe)

Each format specifies particular characteristics for transmitting video; some of these include channel frequency width, number of scanning lines, horizontal and vertical scanning frequency, etc. These formats are not compatible with each other. [Ref. 18: p. 878] This paper will not address technical specifications of the various formats. However, it is important to recognize that the common intermediate format (CIF) and quarter common

[8] JPEG is the Joint Picture Expert Group standard for still picture compression. MPEG is the Motion Pictures Experts Group standard for still or motion video compression.

intermediate format (QCIF) were adopted to overcome the primary video transmission format differences.

CIF and QCIF were adopted to standardize the structure for coding information in a picture (or frame). Each frame is divided into Groups of Blocks (GOBs). The CIF picture is divided into 12 GOBs, while the QCIF is divided into 3 GOBs. Once this initial division occurs, both CIF and QCIF GOBs are treated identically, as follows:

> Each GOB is further subdivided into 33 macroblocks. Each macroblock is further subdivided into six blocks with each block having 64 (8x8) pixels. Four of the blocks provide luminance (brightness) information, while two of the blocks provide chrominance (color) information. [Ref. 15: p. 6]

After applying Discrete Cosine Transform (DCT) techniques, each block is compressed from 512 bits to 25 bits. The receiving decoder reverses the process to create 512 bits, however, with minor differences from the original picture. [Ref. 15: p. 6] [9]

C. INDIVIDUAL VTC COMPONENTS

Any video teleconference (or teletraining) operation consists of four fundamental components:

- video facility -- this might include, but is not limited to the camera, monitor, audio devices, system controlling

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[9] For more extensive treatment of this topic, see Schaphorst, Richard A., "Standards Related To Audiovisual Communications," in *Technical Guide to Teleconferencing & Distance Learning*, edited by P.S. Portway and C. Lane, pp. 105-127, Applied Business teleCommunications, 1992.

equipment, still document projector, video or tape recorder, and associated room equipment such as lighting, chairs, desks, etc.;

- codec or encoder/decoder -- converts the analog signal to digital and compresses the data for transmission at the sending end, and reverses the process at the receiving end;

- transmission network -- either satellite or terrestrial links that carry the (usually digitized and compressed) video signal;

- inverse multiplexer -- required to synchronize data transmission when the transmission requires more than two (56 Kbps or 64 Kbps) channels between terrestrial links. Synchronization on one or two channels is typically handled by the codec.

While the inverse multiplexer is not required for all VTC applications, it appears frequently enough to require inclusion on the list. Satellite video teleconferencing will not use the multiplexer but will instead require equipment dedicated to supporting the satellite link (i.e., amplifiers, upconverters, etc.).

The exact outfit of the VTC suite remains at the discretion of the user. Including a document image transfer device is a good example. One 1992 survey found that 96% of video teleconference participants felt that a still-image document transfer capability would improve the quality of the conference [Ref. 19]. In the Army Video Teletraining Network (TNET) contract, a document image transfer device is included with the standard package.

D. VTC TRENDS

Video teleconferencing is rapidly gaining in popularity. In some ways, the VTC trend is analogous to the facsimile market. For years, facsimile was restrained from gaining wide-scale acceptance because of numerous competing standards. Once industry accepted the CCITT Group 3 standard, the demand for facsimile services rapidly increased. [Ref. 20]

The comparable watershed event for video teleconferencing was the CCITT acceptance in 1990 of the H.320 family of VTC standards [Ref. 20]. Between 1991 and 1992, the two-way video market increased by over 40 percent, jumping from $495 million to $707 million [Ref. 1]. One projection for 1995 estimates video teleconferencing sales in the vicinity of $3 billion, although this figure includes a substantial desktop video teleconferencing component [Ref. 21].

In conjunction with acceptance of the H.320 standards, there is a corresponding decrease in equipment prices and growing user familiarity with the VTC media. Ever since the Gulf War, when corporations used VTC as a safe and reliable substitute for travel, there has been increasing acceptance of VTC throughout the private sector [Ref. 22].

E. VTC NETWORKS

High speed digital data communication links are requisites for two-way video teleconferencing. Virtually all DOD video

teleconferencing applications are satisfied by either terrestrial or satellite communications.

In the private sector, terrestrial communication links to support video teleconferencing might be provided by the local-exchange carrier (LEC--local phone company), the inter-exchange carrier (IXC--long distance phone company), or some other independent service provider. The three largest commercial video teleconference transmission providers are AT&T's Global Business Video Services, Sprint Meeting Channel and the MCI VideoNet.

In DOD, the terrestrial links are provided by FTS2000 or by one of the DOD common-user networks (i.e., DCTN, NAVNET, etc.)[10]

For satellite video teleconferencing (and for one-way distance learning), DOD is essentially no different than the private sector. Satellite transmission is obtained by leasing time from a commercial satellite provider. Satellite video teleconferencing is discussed in additional detail in Chapter VI.

---

[10] There are occasions where DOD commands use an LEC or IXC to support videoconferencing; however, these exceptions will not be included in the scope of this paper.

III. DEVELOPMENT OF VTC IN DOD

A. VIDEO TELECONFERENCING HISTORY IN DOD

One of the earliest uses of video capability was the communications provided between the Situation Room and the Pentagon in the early 80's using a combination of codecs to achieve 44 Mbps video transmission. However, this stand-alone application was the exception rather than the rule.

The beginning of widespread VTC throughout DOD traces its beginnings back to the late 70's/early 80's time frame. In 1979, the Defense Advanced Research Projects Agency (DARPA) began working on designing and developing a VTC system that would support group problem-solving in command and control, and crisis management situations [Ref. 8]. In 1982, DARPA reported the development of an "advanced video teleconferencing system," as part of the command and control research program [Ref. 23].

One of the earliest examples of a DOD remote video application was teletraining in the field of medicine (or telemedicine) in 1982. Brooke Army Medical Center and the Academy of Health Sciences broadcast one-way video to Army-owned receive-only earth stations. The broadcast ran for two hours each day using a satellite uplink from studios located at Fort Sam Houston, Texas. [Ref. 24]

These meager beginnings evolved into an impressive VTC infrastructure. All of the Services have common-user networks in-place that support VTC applications. The Air Force uses its Numbered Air Forces Network to provide VTC connections throughout the Pacific Theater. The Navy has demonstrated VTC applications in medicine, training, and in the operational environment between shore sites and ships. Between the Army Teletraining Network (TNET) and the Satellite Education Network (SEN), there are over 150 remote sites receiving training. The Air National Guard alone is planning over 250 remote teletraining receive sites.

B. CURRENT DOD VTC APPLICATIONS

DOD relies on VTC, not only for internal requirements, but also for applications with the private sector. VTC supported cooperating work groups in DOD and the Aerospace Industry while developing complex weapon systems.

VTC has demonstrated very impressive use during recent operations. VTC contributed in the areas of logistics and training during "Desert Storm." Army and civilian engineers in St. Louis, Missouri, and Mesa, Arizona, were able to see and discuss problems affecting Apache attack helicopters deployed to the Persian Gulf. Design experts were able to begin preparing modifications while the helicopters were still in transit back to the United States [Ref. 25: p. 41]. In the area of training, the Defense

Language Institute used video teleconferencing to provide Arabic language training from Monterey, California, to soldiers stationed in Ft. Huachuca, Arizona and Ft. Hood, Texas [Ref. 26].

C. SECURE VS. NON-SECURE VTC

The greatest deterrent to secure video teleconferencing seems to be the cost of maintaining secure VTC sites, including the corresponding requirement for two-person integrity. Once the decision is made to provide secure VTC facilities at both ends, point-to-point secure video teleconferencing (below the Sensitive Compartmented Information (SCI) level) is usually straightforward. Both the transmitting and receiving sites attach the same model cryptographic device to their respective video teleconferencing units. The signal is encrypted immediately after leaving the sending VTC unit (VTU), and remains encrypted until it reaches the matching cryptographic device attached to the receiving VTU. The receiving cryptographic device decodes the signal for the receiving VTU. MIL-STD-188-331 (draft) requires new VTC equipment to have at least one synchronous RS-449 attachment port, to provide for connection to a cryptographic device.

Secure multipoint VTC communications are more unwieldy. The normal transmission begins exactly the same as the point-to-point example; the signal leaves the transmitting VTU and

immediately encrypted. The problem appears with the multipoint control unit (MCU) that coordinates data transmission for all VTC sites in the conference. The MCU must receive an unencrypted signal, so the MCU requires a cryptographic device to process the encoded signal. After the signal is routed and before the signal reaches the outbound transmission line (network), the signal must be encrypted again (as it leaves the MCU). This essentially requires one cryptographic unit at the MCU for each site involved in the secure multipoint conference (i.e., 6 sites, 6 individual cryptographic units). Also, the MCU must now become a secure VTC facility and that introduces more costs. [Ref. 27]

MIL-STD-188-331 describes three levels of security for information transmitted between VTC units:

- Unencrypted. This applies to information that is unclassified and also not sensitive. All VTC units must be able to transmit and receive unencrypted data.
- Unclassified but sensitive (Type 3). Type 3 cryptographic equipment (certified by NIST) will be used to encrypt data in this category. Information exempted by the Warner Amendment is not included in this category.
- Classified (Type 1). Type 1 cryptographic equipment (certified by NSA) will be used to encrypt data that is classified, or data that is considered sensitive within the guidelines of the Warner Amendment. [Ref. 3: . 55]

Both the KG-84 and KG-194 devices (or similarly compatible devices) are acceptable for Type 1 encryption.

Note that the previous descriptions pertain only to "collateral" systems; that is systems that are only certified for security levels below the SCI level. There is currently no acceptable method for interconnecting collateral VTC systems to a SCI system. [Ref. 13]

The only VTC system currently approved for SCI level communication is the Joint Worldwide Intelligence Communications System (JWICS).

Some models provide encryption only while using their proprietary algorithm. For example, the Rembrandt II/VP does not provide encryption in the CCITT mode. [Ref. 28]

D. VIDEO TELECONFERENCING DIRECTIVES

There are numerous guidelines and regulations that affect the procurement and operation of VTC equipment in DOD. The following sections provide a summary of the guidance that is provided.

1. FIPS PUB 178

Federal Information Processing Standards Publication 178 (FIPS PUB 178) is entitled "Video Teleconferencing Services at 56 to 1,920 Kb/s," and provides guidance related to video conferencing and video telephony. FIPS 178 adopts the following CCITT recommendations that pertain to video teleconferencing:

- H.320. "Narrow-band Visual Telephone Systems and Terminal Equipment, 1990."

- H.221. "Frame Structure for a 64 to 1,920 kbit/s Channel in Audiovisual Teleservices, 1990."
- H.242. "System for Establishing communication Between Audiovisual Terminals Using digital Channels up to 2 Mbit/s, 1990."
- H.261. "Video codec for Audiovisual Services at px64 kbit/s, 1990."
- H.230. "Frame Synchronous Control and Indication Signals for Audio=visual systems, 1990."

The overall relationship between the various standards is better appreciated in Figure 3.

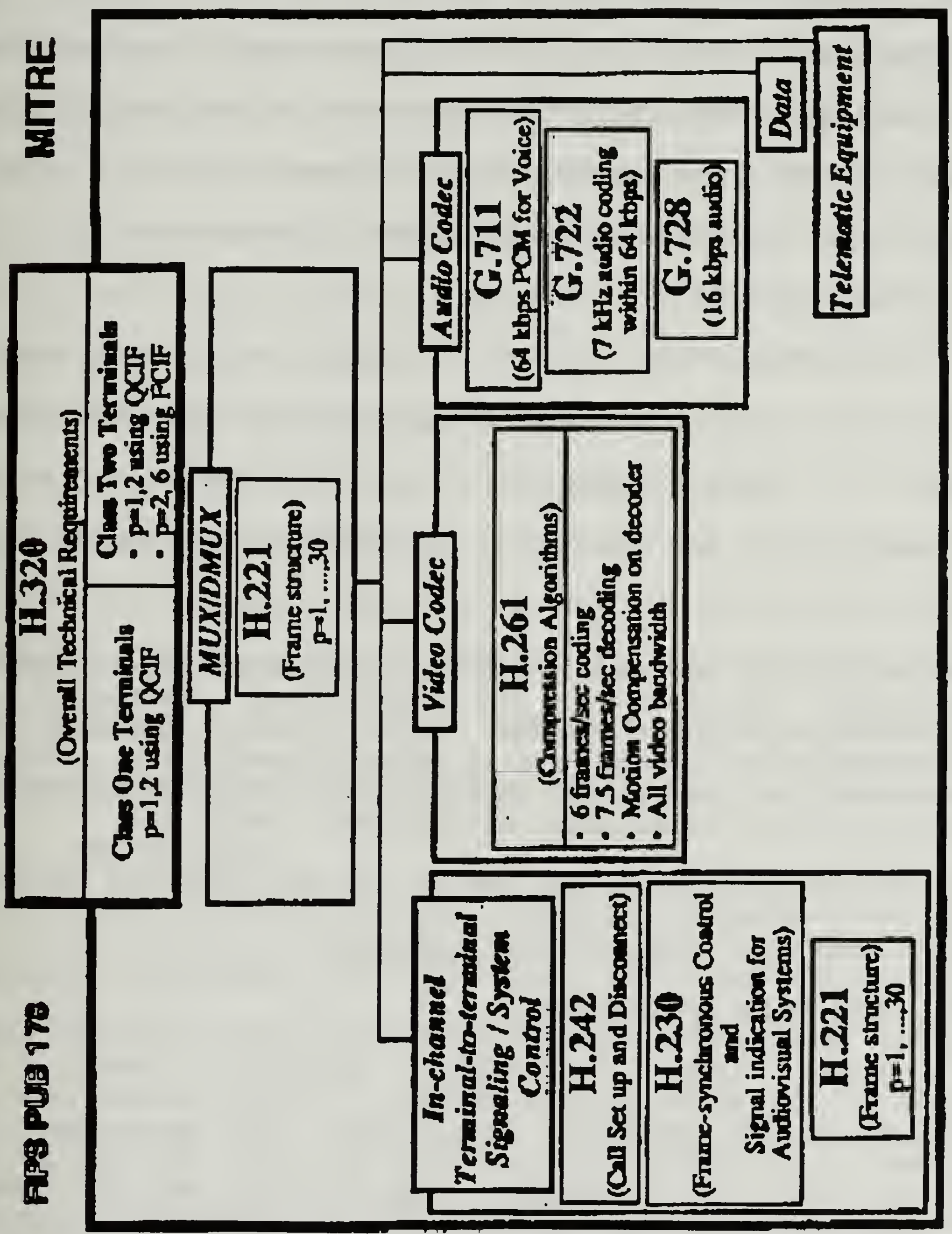

Figure 3 Summary of FIPS 178 Standards [Ref. 15: p. 4]

FIPS 178 includes Military Standard 188-131, "Interoperability and Performance Standard for Video Teleconferencing," as one of its related documents. FIPS 178 was accepted and published by the National Institute of Standards Technology (NIST) in December, 1992; six months later (June, 1993), it became mandatory for all Federal departments and agencies.

2. DOD 4640.11

DOD Directive 4640.11 concerns "Mandatory Use of Military Telecommunications Standards in the MIL-STD-188 Series." This directive is designed to ensure interoperability and guarantee performance standards within DOD.

> The MIL-STD-188 series addresses telecommunications design parameters, influences the functional integrity of telecommunications systems and their ability to interoperate efficiently with other functionally similar Government and commercial systems, and shall be mandatory for use within Department of Defense. [Ref. 29]

This Directive mandates the use of the MIL-STD-188 series in <u>all</u> DOD Component systems and equipment.

3. DOD 4640.12 (draft)

Draft DOD Directive 4640.12, deals with "Teleconferencing Systems, Activities, and Networks." If approved, this will become required by MIL-STD-188-331 (draft). However, Directive 4640.12 has been in a "draft" status since July, 1990.

4. DOD 4640.13

DOD Directive 4640.13, issued 5 December 1991 by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, deals with "Management of Base and Long-Haul Telecommunications Equipment and Services." The directive mandates DOD to be effective and efficient in employing base and long-haul telecommunications, and to discontinue using methods and services that are not effective. DOD common-user systems (i.e., DCTN, NAVNET, AFNet, etc.) are considered exemptions from the requirement to use FTS2000. Similarly, exempt long-haul telecommunications requirements should be normally handled using one of the common-user systems. New acquisition of long-haul telecommunications are acceptable if the requirements "..cannot be satisfied (technically, operationally, cost-effectively) by the DOD common-user systems or FTS2000." [Ref. 30]

5. DOD 4640.14

DOD Directive 4640.14, issued 6 December 1991 by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, deals with "Base and Long-Haul Telecommunications Equipment and Services." Although this directive restates much that it is 4640.13, there are some subtle differences. Whereas Directive 4640.13 deals with <u>policy</u>, Directive 4640.14 provides <u>policy guidelines</u> and "prescribes procedures." Some of the Defense Information

Systems Agency (DISA) responsibilities under Directive 4640.14 include the following:

- review telecommunications billing arrangements at least annually to rationalize common-user network billing arrangements;
- receive requests from DOD Components for all long-haul telecommunications equipment and services;
- conduct lease versus purchase comparisons to determine the best acquisition strategy;
- determine whether requirements will be satisfied using DOD common-user systems or FTS2000;
- approve or disapprove all requests from DOD Components for exceptions from using common-user networks.

The following requirements are exempted from mandatory use of DOD common-user systems:

- communications for real time control (i.e.,satellite control, telemetry),
- operational requirements that are less than 1 year in duration,
- communications in support of exercises,
- base communications and local communications involving locations within the local calling area, and
- teletype circuits with line speeds of 150 bauds or less. [Ref. 31]

An "Exemption Determination" block diagram is included as an enclosure to help provide additional guidance for determining situations that warrant exemptions.

6. DSN FY 92-97 Program Plan

The former Defense Communications Agency (DCA) (now DISA) promulgated a "Defense Switched Network Program Plan: FY 1992-1997" in April 1991.[11] This document is significant for two reasons:

- it recognizes DSN as the primary command and control video teleconferencing network in DOD, and
- it officially recognizes the role of the Defense Commercial Communications Office (DECCO) in telecommunications procurements.[12] [Ref. 32: p. 2-4]

Some functions DECCO is specifically authorized to perform include the following:

- establish contractual arrangements with companies in the communication industry for services constituting the Defense Switched Network (DSN) backbone;
- pay the bills received from vendors supplying the DSN backbone service;
- bill the users of the network on a monthly basis;
- provide funds from the Communications Services Industrial Fund (CSIF) to support the acquisition of government furnished equipment and leased DSN switches. [Ref. 32: p. 5-2]

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[11] The short title is "DSN P/P FY 92-97" dated April 1991.

[12] DECCO is also referred to by a newer name, DISA Information Technology Procurement Organization (DITPRO). However, DECCO seems to be more frequently used throughout DOD.

From a practical standpoint, any new long-haul telecommunications requirements are supposed to go through DECCO. This means that any FTS2000 requirements as well as new DSN requirements go through DECCO. DECCO can do solicitations, take bids from contractors, or actually provide VTC facilities, equipment, rooms, codecs, cameras, etc. Any federal entity is authorized to purchase from the DECCO contract. [Ref. 33]

DECCO does not receive appropriated funds, but rather is a "fee for service" organization. DECCO's fee is 2 percent, based on the amount of the contract award. DECCO currently manages approximately 89,000 contracts worth an estimated $1.4 billion. [Ref. 33]

7. MILSTD 188-331 (draft)

Military Standard 188-331 (draft as of November, 1993), "Interoperability and Performance Standard for Video Teleconferencing," is intended to address DOD requirements not covered in prevailing VTC standards. While current VTC standards move toward interoperability, they do not address the areas of graphics, data and security, that are of specific concern to the DOD.

MIL-STD-188-331 describes two classes of VTC systems:

- non-secure desktop and videophone applications, and
- all other systems.

The military standard prescribes mandatory items that must be included in future VTC procurements. Selected highlights from the mandatory features include the following:

- Full-duplex mode of operation,
- Transmission speed between 56 Kbps and 128 kbps,
- QCIF picture quality and decoding of 7.5 pictures per second,[13]
- Freeze-frame video capability,
- Minimum of one synchronous RS-449 attachment port, and
- Data communications interface to support communications between Data Terminating Equipments (DTE's); an EAI-232-D (formerly RS-232) data port is required. [Ref. 3: pp. 31-47]

MIL-STD-188-331 does not address such VTC related areas as analog VTC, conference scheduling, multipoint VTC and broadcast modes of operation.

DOD circulated the draft military standard to private industry so that the draft might be endorsed by the private sector before being submitted to U.S. and international standards groups for their review. Once the standard is formally approved, exceptions will only be allowed after obtaining a written waiver from DISA. [Ref. 34]

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[13] Picture resolution actually requires the video codec to provide full-color, near-full motion capability.

8. The "Castleman Memorandum"

The "Castleman Memorandum" (ASD-C3I policy) is an October, 1993 memorandum formally titled, "Department of Defense (DOD) Policy for Videoteleconferencing (VTC) Management, Acquisition, and Standards." The memorandum applies to "all DOD VTC activities and capabilities" that require data transmission rates between 56 Kbps and 1.92 Mbps. All DOD VTC services must be "fully operable" with the DISN. DISA is tasked with maintaining a list of acceptable VTC equipment and with providing DOD components with the means for contracting both equipment and services.[14] FIPS 178, Interim Planning Standard 187-331 and eventually MIL-STD-133-331 ("Interoperability and Performance Standard for Videoteleconferencing") are all mandatory standards within this policy. The policy mandates using the Joint Worldwide Intelligence Communications system (JWICS) for all intelligence activities that have SCI-secure VTC requirements. [Ref. 35]

DISA has developed a voluntary "Video Teleconferencing Requirements Questionnaire" to assist DOD users with determining VTC requirements. The questionnaire describes five categories of video teleconferencing:

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[14] As a practical matter, DISA uses the Defense Commercial Communications Organization (DECCO) to contract for equipment and services.

- Multi-Point Video Telebroadcast. This is one-way video-one-way audio and is typically (but not exclusively) associated with a satellite broadcast.

- Multi-Point Video Teleseminar (sometimes referred to as "n-way"). This is one-way video, two-way audio.

- Point-to-Point Teleconferencing. This is two-way video, two-way audio between two stations.

- Selective Presence Multi-point Video Teleconferencing. All stations must be capable of two-way video. One station acts as "conference chairman;" this station transmits to all receiving sites and designates a second station that can also be viewed. Receiving sites can select to see either the "conference chairman," or the second station, or both.

- Continuous Presence Multi-point Video Teleconferencing. Each station transmits its own video signal to all other conferees; video from all sites is simultaneously displayed on all screens in a "Hollywood Squares" -type arrangement. [Ref. 35]

Figures 4-8 provide examples of each of the five categories [Ref. 36].

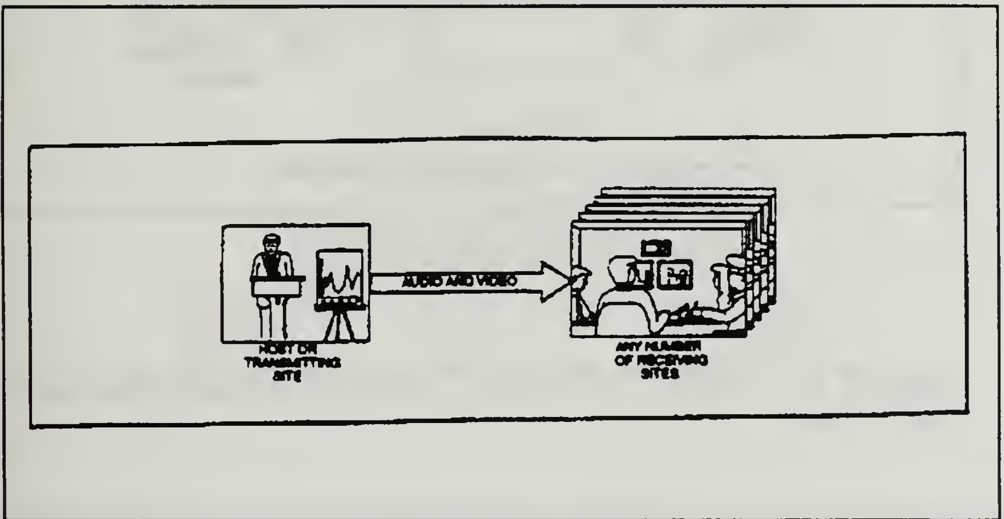

Figure 4 Multi-Point Video Telebroadcast [Ref. 36]

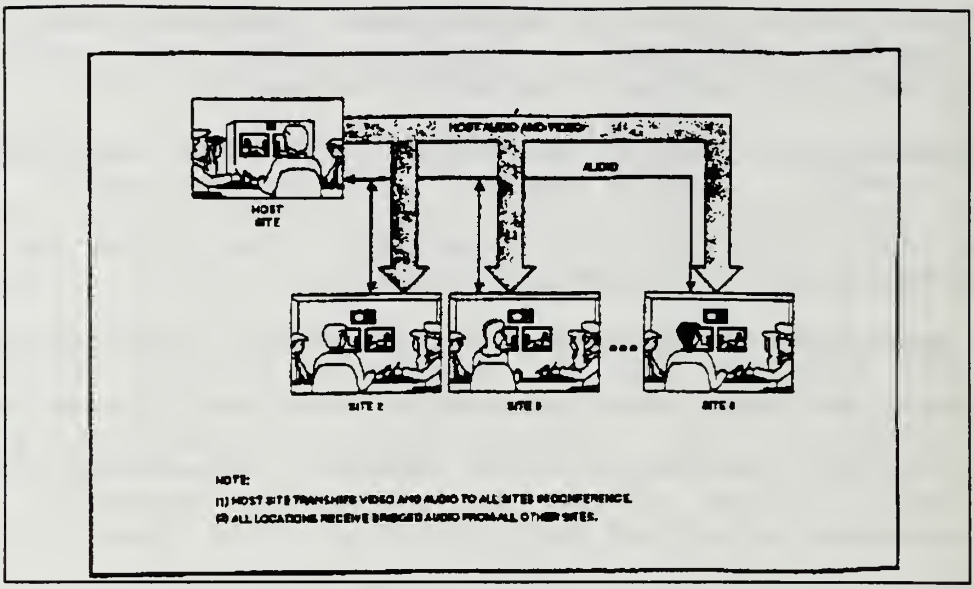

Figure 5 Multi-Point Video Teleseminar [Ref. 36: annotated]

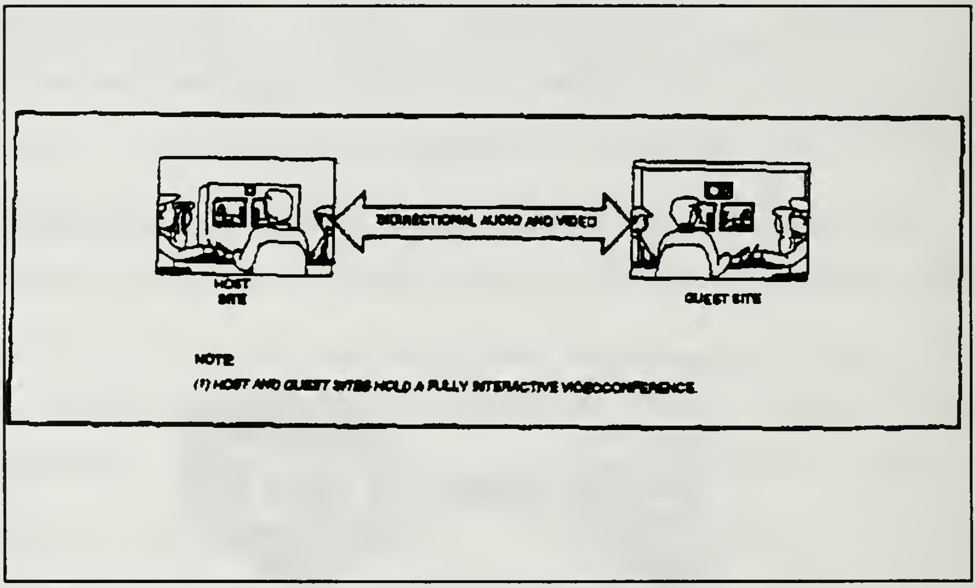

Figure 6 Point-to-Point Video Teleconferencing [Ref. 36]

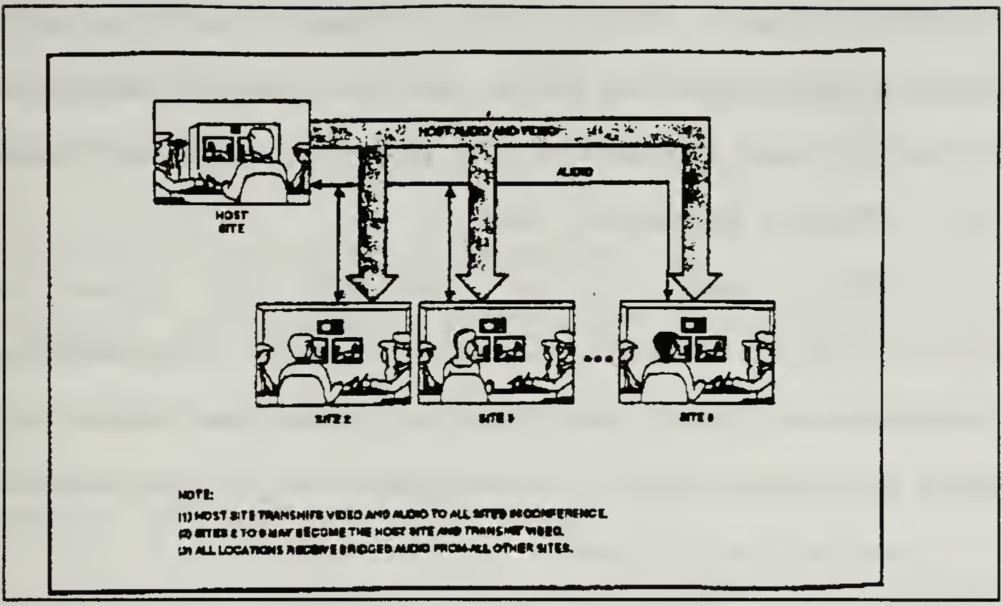

Figure 7 Selective Presence Multi-point Video Teleconferencing [Ref. 36]

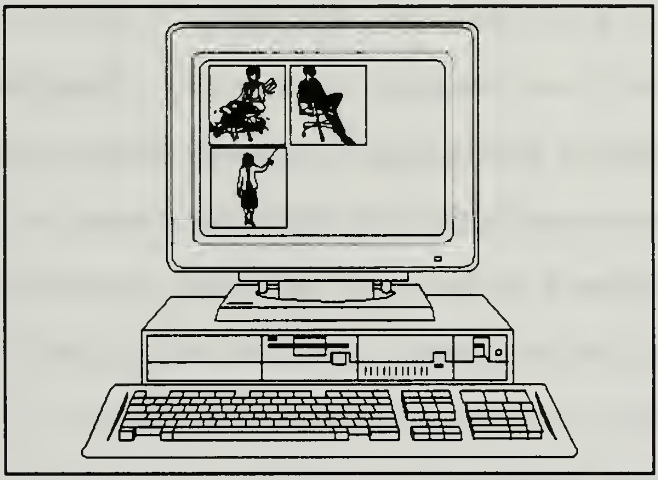

Figure 8 Continuous Presence Multi-Point Video Teleconferencing

Service within the five DISA categories can be provided using satellite or terrestrial communication links (relative advantages and disadvantages of both delivery methods will be

discussed later). While one use might favor a particular delivery method over the other, both satellite and terrestrial links can be used for any of the previously listed categories.

9. FTS2000 Mandatory Use

Public Law 101-136 [Section 621] prescribes the mandatory use of FTS2000 "to meet Federal telecommunications requirements unless GSA (General Services Administration) granted an exception." An exception might be granted under the following conditions:

- the service cannot be provided by FTS2000, and
- the agency can conduct a cost-effective procurement.

A related requirement covers procurements of equipment or services not provided by FTS2000. There is currently no delegation of procurement authority (DPA) for procurements coincident with a GSA exemption from FTS2000 use. Procurement requests less than $250,000 must be submitted to GSA Service Oversight Center for Network "A" (GSA SOC A); procurements for $250,000 or more must go through GSA's Authorization Branch (KMAS).

10. Warner Exemption

The Warner Amendment (Title 10, United States Code, Section 2315), is a modification to the Federal Property and Administrative Services Act (Section 111). The Warner Amendment effectively exempts specific types of

telecommunications applications from the mandatory use provisions of FTS2000, if the "function, operation, or use" of those applications:

- involves intelligence activities;
- involves cryptologic activities related to national security;
- involves the command and control of military forces;
- involves equipment that is an integral part of a weapon or weapons system; or
- is critical to the direct fulfillment of military or intelligence missions (specifically excluded from exemption within this category, are applications that involve the procurement of Automatic Data Processing Equipment (ADPE) or services to be used for routine administrative and business applications, including payroll, finance, logistics, and personnel management applications). [Ref. 3]

E. DOD VTC NETWORKS

There are numerous networks operating in DOD that employ or support VTC in some form or another. Several DOD networks, such as DCTN, NAVNET and FTS2000 will be examined in greater detail in later chapters. The following examples are not all-inclusive, but provide brief descriptions of selected DOD VTC networks.

1. VIXS

The Video Information Exchange System (VIXS) is a VTC system designed to support Navy administrative and tactical commanders. The system conforms to the H.261 standard and is

designed to support transmission speeds between 112-384 Kbps in the multipoint mode, and between 56-384 Kbps in the point-to-point configuration. VIXS is compatible with NAVNET and has access to the DCTN via an analog bridge located at CINCLANTFLT Norfolk, Virginia. [Ref. 37]

Figure 9 provides a conceptual view of a version (including transmission speeds) of the VIXS VTC net. Figure 10 provides a conceptual view of connections between VIXS and the Defense Commercial Telecommunications Network (DCTN).

The primary VIXS hub is the secure multipoint control unit (MCU) at Hampton Roads, Virginia; a second secure MCU will be at Pearl Harbor, Hawaii. *Timeplex* multiplexing equipment is planned for all sites to support real-time bandwidth management. VIXS accepts transmissions classified up to the Secret level; VIXS users are required to use the KG-194 encryption device. [Ref. 37]

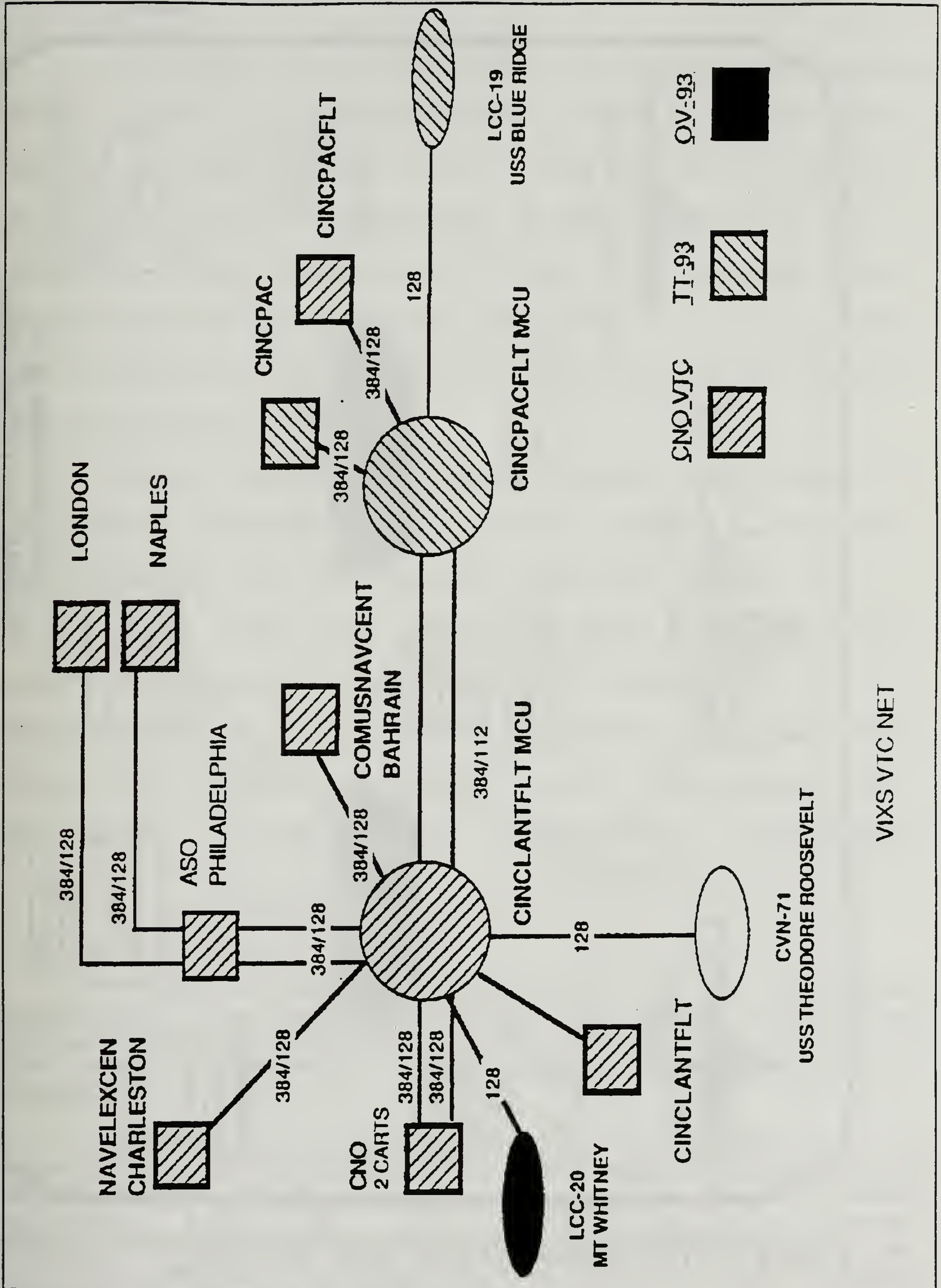

Figure 9 VIXS VTC Net [Ref. 42]

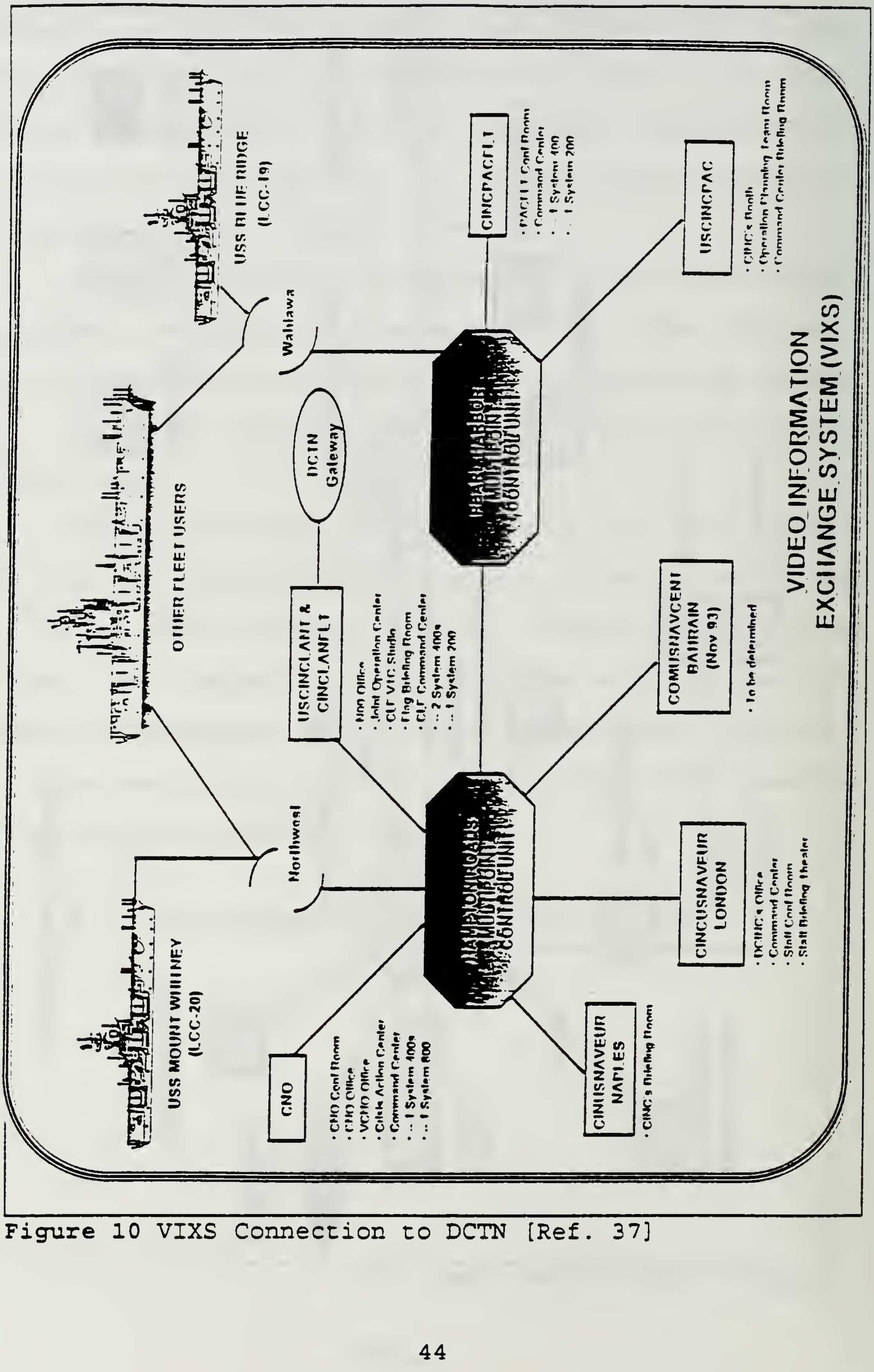

Figure 10 VIXS Connection to DCTN [Ref. 37]

2. AFnet

The Air Force Integrated Data Telecommunications Network (AFnet) is a 10 year contract with N.E.T. Federal Inc. that was awarded in 1991. AFnet is not so much a VTC network as it is a leased communication service over which VTC is possible. AFnet combines six different data networks into a single architecture to support voice, data and video traffic over the same network. Dedicated lines are provided by both DCTN and FTS2000. [Ref. 38]

AFnet supports classified traffic and allows for priority and override calls to preempt circuits as required. The backbone of the network consists mostly of T-3 (44.736 Mbps) lines with T-1 (1.544 Mbps) lines providing alternate routing and "tail circuits."[15] AFnet uses N.E.T.'s IDNX multiplexers to connect private branch exchanges (PBXs) using an ISDN Primary Rate Interface (PRI). [Ref. 39][16] The ISDN implementation effectively

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[15] "Tail circuits" are the portion of the high speed transmission line that runs from the user facility ("service delivery point") to the location that provides the link to the high speed transmission infrastructure (i.e. a point-of-presence).

[16] ISDN is the Integrated Services Digital Network. PRI is an ISDN service that divides a 1.544 Mbps T-1 link into 23 user B channels (64 Kbps lines) and a single 64 Kbps D channel for control signalling. ISDN customers can use an inverse multiplexer to mix and match channels for different uses (i.e. 17 64 Kbps channels for phone service with 6 64 Kbps channels aggregated to form a 384 Kbps video link).

provides bandwidth on demand to support video transmissions at speeds in multiples of 64 Kbps between 64-1472 Kbps.

3. Defense Simulation Internet

The Defense Simulation Internet (DSI) is a worldwide special-purpose network managed by the Advanced Research Projects Agency (ARPA). DSI was designed as a high-speed network to support transmitting simulation and wargaming data between wargaming centers. The network currently provides VTC capability as part of the wargaming and simulation between over 40 locations within DOD. Information on DSI can be classified to the Secret level.

4. Numbered Air Forces Network

This is a dedicated VTC network designed to support the Pacific Command. The Numbered Air Forces Network links the following Air Force Bases (AFBs): Osan AFB, Korea; Yokota AFB, Japan; Elmendorf AFB , Alaska; Anderson AFB, Guam and Hickam AFB, Hawaii. Figure 11 shows the geographical relationship between the bases [Ref. 40].

Figure 11 Numbered Air Forces Network [Ref. 40]

The network can handle secure communications to the Secret level and normally operates at 128 Kbps. Since the network was designed to exclusively serve the Pacific Theater, there was no connection to the continental U.S. Future plans are to provide CONUS connections via a T-1 line from Trippler AFB in Hawaii.[17]

5. JWICS

The Joint Worldwide Intelligence Communications System (JWICS) is managed by the Defense Intelligence Agency (DIA). JWICS was designed to provide secure VTC between DOD indications and warning system members of Unified and Specified Commands within the United States and overseas. Each respective operating command is responsible for the physical security of JWICS equipment installed at the command.

Typical JWICS employments includes the following:

- real-world crisis/strategic activity,
- Soviet military activity,
- exercises,
- Watch Center exchanges, and
- executive use and VIP demonstrations on a noninterfering basis. [Ref. 41: p. 6-52]

In 1991, the JWICS primary transmission medium was commercial leased satellite communications [Ref. 41: p. 6-52].

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[17] The Pacific Command VTC arrangement will be discussed in more detail in the final chapter of this paper.

The "Castleman Memorandum" mandates JWICS use for all intelligence activities that require SCI-secure VTC applications. JWICS can transmit either SCI-approved or collateral modes. Currently, JWICS is the only VTC system approved for SCI level communication.

IV. VIDEO TELECONFERENCING ON DCTN

A. DCTN BACKGROUND

The Defense Commercial Telecommunications Network (DCTN) is the largest DOD common-user network. It is a command and control network established in March, 1986, through a ten year contract with AT&T, under the management of the Defense Communications Agency (DCA) (now DISA) [Ref. 25: p. 42], [Ref. 42: p. 60]. DOD provided the following principal objectives for DCTN in the original Request For Proposals (RFP).

> ... lease satellite transmission capacity and wideband terrestrial capacity which can be rapidly and flexibly allocated to meet the needs of National Command authorities, the DOD, and the military departments under crisis and emergency conditions.... [Ref. 43]

The following attributes are considered integral DCTN features:

- integrated voice, data, and multipoint video in a digital network;
- single point of contact for end-to-end service with centralized operation and maintenance;
- integrated, centrally controlled, all-digital network;
- reconfigurable network capacity to meet user demand;
- secure transmission via digital encryption standard (DES);
- protection of satellite links for network privacy;

- integral part of the Defense Switched Network (DSN). [Ref. 41: p. 6-16]

DCTN was originally used as an inter-Service communications link to support various components, or "communities of interest" within DOD that required frequent interactive high-speed data transmission. The first DCTN user was the Army Materiel Command in 1986, and it was shortly joined by Air Force Logistics Command, Air Force Systems Command, Headquarters Department of the Army, Army Forces Command, Naval Air Systems Command, AEGIS Navy Command and the Strategic Defense Initiative (SDI) Command. [Ref. 42: pp. 60-62]

DCTN was originally a satellite-based network. As land-lines became more abundant and more affordable, the network evolved from satellite-based to its current state of primarily using terrestrial-based fiber-optic links.[18]

The current DCTN contract is scheduled to expire in March 1996. A likely scenario is that the contract will be extended on a month to month basis until it is replaced by the Defense Information Systems Network (DISN). [Ref. 44]

DCTN was recognized for "The Most Significant Advance In Two Way Motion Videoconferencing" in 1991 [Ref. 45].

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[18] It is only recently that DCTN offered a video satellite-based service, "Compressed Digital Video Service." This feature is discussed in greater detail in Chapter IV.

B. DCTN INFRASTRUCTURE

Video teleconferencing (VTC) on the DCTN is based on Compression Labs Inc. (CLI) products, so there are a preponderance of CLI devices on the network. VTC can occur between CLI and non-CLI devices if both are operated in the "standards mode" -- compliant with H.261.[19]

DCTN has two gateway connections, one each in Anaheim, California and Washington, D.C., for links to other networks. Currently, there is no direct gateway connection between DCTN and FTS2000. DCTN and FTS2000 can conduct a VTC by accessing the Sprint Meeting Channel gateway. The DCTN Network Control Center (NCC) is located in Dranesville, Virginia.

There are over 140 DCTN video rooms on the network, including connections to Hawaii. A listing of all DCTN VTC user locations is provided in Appendix C. Currently, there are no VTC connections to Alaska without making special arrangements. There are also no VTC connections to Europe. However, a pending DCTN "switched-service" proposal to the Defense Commercial Communications Office (DECCO) might lead to international VTC using DCTN. [Ref. 46]

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[19] The CLI Rembrandt I is a notable exception. Rembrandt I is not interoperable with the H.261 standard.

C. DCTN VIDEO TELECONFERENCING

1. Regulations Regarding DCTN Use

DCTN is a command and control network. As such, it is included within the guidelines provided by the Warner Amendment for exceptions to mandatory FTS2000 use. Every service provided by DCTN must be ordered through DECCO [Ref. 46].

DCTN VTC is entirely driven by user requirements. DCTN only provides special services or additional features in response to user requests. Each Branch of the Services has established specific procedures for submitting new VTC requirements to DCTN. [Ref. 46]

2. Capability

DCTN provides for a range of VTC speeds (in increments of 64 Kbps) up to the limit of the user bandwidth. The maximum user bandwidth for the network is full T-1 (1.544 Mbps).

DCTN provides both Point-to-Point VTC and "Interactive Multipoint."[20] During the "Interactive Multipoint" session, the "chairman" designates the site that will be seen by all sites. Up to 25 sites can simultaneously participate in the "Interactive Multipoint" session [Ref. 47]. The

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[20] "Interactive Multipoint" is a slight variation from "Selective Presence Multi-point" VTC as described in Chapter II. "Interactive Multipoint" only allows one site to be seen during the multi-point VTC.

audio is "fully-bridged" at all times for all sites in a non-secure session [Ref. 48].[21] In a secure VTC, DCTN uses a central bridge that provides a "seen to be heard" format. Only audio from the displayed site is transmitted.[22]

DCTN provides twenty-four hour video teleconference capability. Reservations are still required for a video teleconference to provide time to schedule the call in the network control system. However, reservations are guaranteed by contract with at least one hour advance notice. The video portion of DCTN is non-preemptible, so a VTC will not be interrupted by a higher priority request for the line [Ref. 46].

DOD video applications on DCTN include the following:

- Command and Control,
- Training/Distance Learning,
- Project Administration,
- Crisis Management,
- Contract Administration, and
- Recruiting [Ref. 49].

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[21] "Fully-bridged" means that all sites in the video teleconference can always be heard, regardless of whether or not their site is the one being viewed at any particular time.

[22] In "seen-to-be-heard" mode, a third site can only receive audio from the site displayed on their screen. They cannot hear other sites in the conference when those sites are not displayed.

Currently, switched service (dial-up bandwidth) is not available on the DCTN (although AT&T has submitted a proposal to DECCO to provide this service) [Ref. 50].

3. Equipment Required For VTC

Strictly speaking, DCTN refers to the transmission links; it does not provide any VTC equipment. However, DECCO has negotiated a Communication Service Authorization (CSA) with AT&T to provide a wide range of VTC services and equipment for DCTN users. DCTN users can also buy video equipment from other sources in addition to using the DECCO CSA.

The majority of codecs on DCTN are CLI Rembrandt models; these are the only models available on the DECCO contract with AT&T. Prices for the three basic systems range from $29,700 to $45,100. The AT&T standard video system also comes with over 60 options, providing such additional features as multipoint capability, secure transmission (using a KG-194 interface), assorted levels of codec conversion and picture quality, camera, audio and graphics options, etc.

Different levels of codec capability and compatibility on the DECCO-AT&T contract are provided by different "applications packages." A widespread problem throughout DOD is a profusion of older CLI Rembrandt I models that are not

compliant with the FIPS 178 (H.261) codec standards.[23] "Application Package 4" is the minimum required option that provides interoperability with the older Rembrandt I units.[24] Price for a new unit with "Application Package 4" is around $49,000. [Ref. 51]

4. Associated Costs

Currently, DCTN provides a firm-fixed, dedicated service; that is the user pays a fixed monthly fee regardless of the number of calls, distance between DCTN VTC sites, or the amount of connect time. This fee method generally supports high usage rates. AT&T and DECCO are presently negotiating a proposal for switched service that includes multi-point call capability for low-bandwidth transmissions (384 Kbps or less). [Ref. 50]

The following costs are associated with using a DCTN line:

- (one-time) hook-up fee and network installation;
- (one-time) multipoint capability;

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[23] The "Castleman Memorandum" requires existing DOD VTC components to be upgraded "as necessary" to comply with MIL-STD-188-331 within one year of its approval. DOD components that only require communications with Rembrandt I units, could conceivably continue using those units for the remainder of their useful service life and still be in compliance with the DISA guidance.

[24] All four "applications packages" provided by AT&T use the CLI Rembrandt model II/VP. Only "Application Package 4" provides backward compatibility with the Rembrandt model I.

- (recurring) monthly line charge (based on bandwidth and distance from user to the nearest DCTN node).

DCTN reviews each situation on a case by case basis before assigning the monthly charge. There are instances of facilities within 15 miles of a node that pay the same rate as a facility co-located with the node. Monthly T-1 line charges range between $8,000 and $20,000 with the median T-1 line charge between $10,000 and $11,000.[25] [Ref. 46]

There are no additional fees for encryption. Table III provides sample costs associated with DCTN video teleconferencing.

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25 The most expensive DCTN monthly line charge is to Fort Polk, Louisiana, located almost 400 miles from the nearest DCTN node.

Table III DCTN ASSOCIATED COSTS

DCTN COST ESTIMATES (nearest $00):

****

[DCTN Cost Estimates do NOT include VTC equipment costs]
[These costs do NOT include the DECCO 2% administrative fee]

<u>One-time Costs:</u>		<u>1st Year</u>	<u>Add'l Years</u>
- Network Installation / Hook-up		$22,600	$0
- Multipoint Capability		$3,000	$0
<u>Recurring Cost Estimates:</u>			
- Monthly Line Charge & "tail fee" (user is co-located with DCTN node)			
T-1	($8,000 /mo x 12)	$96,000	$96,000 / yr
768 Kbps	($6,000 /mo x 12)	$72,000	$72,000 / yr
384 Kbps	($3,500 /mo x 12)	$42,000	$42,000 / yr
(based on 91 miles to nearest DCTN node -- Monterey, California to San Francisco, California)			
T-1	($13,000 /mo x 12)	$156,000	$156,000 / yr
768 Kbps	($11,700 /mo x 12)	$140,400	$140,400 / yr
384 Kbps	($8,000 /mo x 12)	$96,000	$96,000 / yr

DCTN Total Costs (1 site):

[DCTN Cost Estimates do NOT include VTC equipment costs]

- (user is co-located with DCTN node)			
T-1	($8,000 /mo x 12)	$121,600	$96,000 / yr
768 Kbps	($6,000 /mo x 12)	$97,600	$72,000 / yr
384 Kbps	($3,500 /mo x 12)	$67,600	$42,000 / yr
(based on 91 miles to nearest DCTN node -- Monterey, California to San Francisco, California)			
T-1	($13,000 /mo x 12)	$181,600	$156,000 / yr
768 Kbps	($11,700 /mo x 12)	$166,000	$140,400 / yr
384 Kbps	($8,000 /mo x 12)	$121,600	$96,000 / yr

[Ref. 50]

The DCTN contract includes an annual cost review to ensure rates are competitive with other industry communications offerings.

V. VIDEO TELECONFERENCING ON NAVNET

A. NAVNET BACKGROUND

NAVNET is a Navy Common User Network that evolved from the Data Automation Command Network (DACNET). Originally, a low speed circuit network, NAVNET was established by the Naval Computer and Telecommunications Command (NCTC) to provide long-haul circuit integration for Navy users. [Ref. 52]

NAVNET services are divided into three basic categories:

- Packet-switched users of the Defense Data Network (DDN),
- Full-period users; that is dedicated (24 hour) bandwidth, and
- Video teleconference users. [Ref. 53]

B. NAVNET INFRASTRUCTURE

NAVNET is comprised of T-1 lines leased from the DCTN. Technically, the NAVNET contract expires with the expiration of DCTN in March 1996.

C. NAVNET VIDEO TELECONFERENCING

1. Regulations Regarding NAVNET Use

NAVNET is an approved DOD common-user network and as such can be used without impunity. Connections can be established by working with NCTC. NCTC might connect the

users themselves or recommend a plan for submitting a request through DISA for a longer-term solution. If NCTC can satisfy the requirement, chances are the capability will become available much sooner than going through other procurement vehicles.

2. Capability

NAVNET capability is similar to that of DCTN. NAVNET provides for a range of VTC speeds (in increments of 64 Kbps) up to the limit of the user bandwidth. The maximum user bandwidth for the network is full T-1 (1.544 Mbps).[26] The common NAVNET VTC speed is 384 Kbps.

NAVNET enjoys the same capabilities as DCTN; that is, both can provide either Point-to-Point VTC or "Interactive Multipoint" VTC sessions. Current capacity of NAVNET for a multipoint conference is 16 ports. This number might be increased by concatenating up to three multipoint control units at the NAVNET hub, however, this is not considered a standard mode of operation.

NAVNET provides twenty-four hour video teleconference capability. Reservations are required to provide time for NCTC to schedule bandwidth for the VTC. Reservations can be made with as little as 24 hours advance notice. However,

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[26] Although NAVNET is capable of bandwidth up to full T-1 (1.544 Mbps), there are usually technical limitations that preclude the entire T-1 for a video teleconference. The practical high-end limit is 1.152 Mbps (or 18 DS0 (64 Kbps) channels).

since access is not guaranteed, NCTC prefers as much advance notice as possible.

NAVNET can be set up as either a dedicated, non-preemptible basis (as is the case for the Chief of Naval Operations (CNO)), or NAVNET can be configured so that calls are on a priority basis [Ref. 27]. DOD video applications on NAVNET are essentially the same as those listed for DCTN. Figure 12 provides the locations of NAVNET nodes [Ref. 54].

3. Equipment Required For VTC

The majority of codecs on NAVNET are PictureTel units and these are mostly operated at speeds of 768 Kbps and below (with 384 Kbps being used most often). However, NAVNET lines can accommodate virtually all codecs. The limitation exists only between the sites communicating during the particular conference.

4. Associated Costs

The NCTC Comptroller provides a posted tariff for services up to 56 Kbps. Charges above 56 Kbps are not so much a tariff as they are guidelines. Generally, NAVNET tries to hold costs in line with FTS2000 for services that are 128 Kbps or greater.

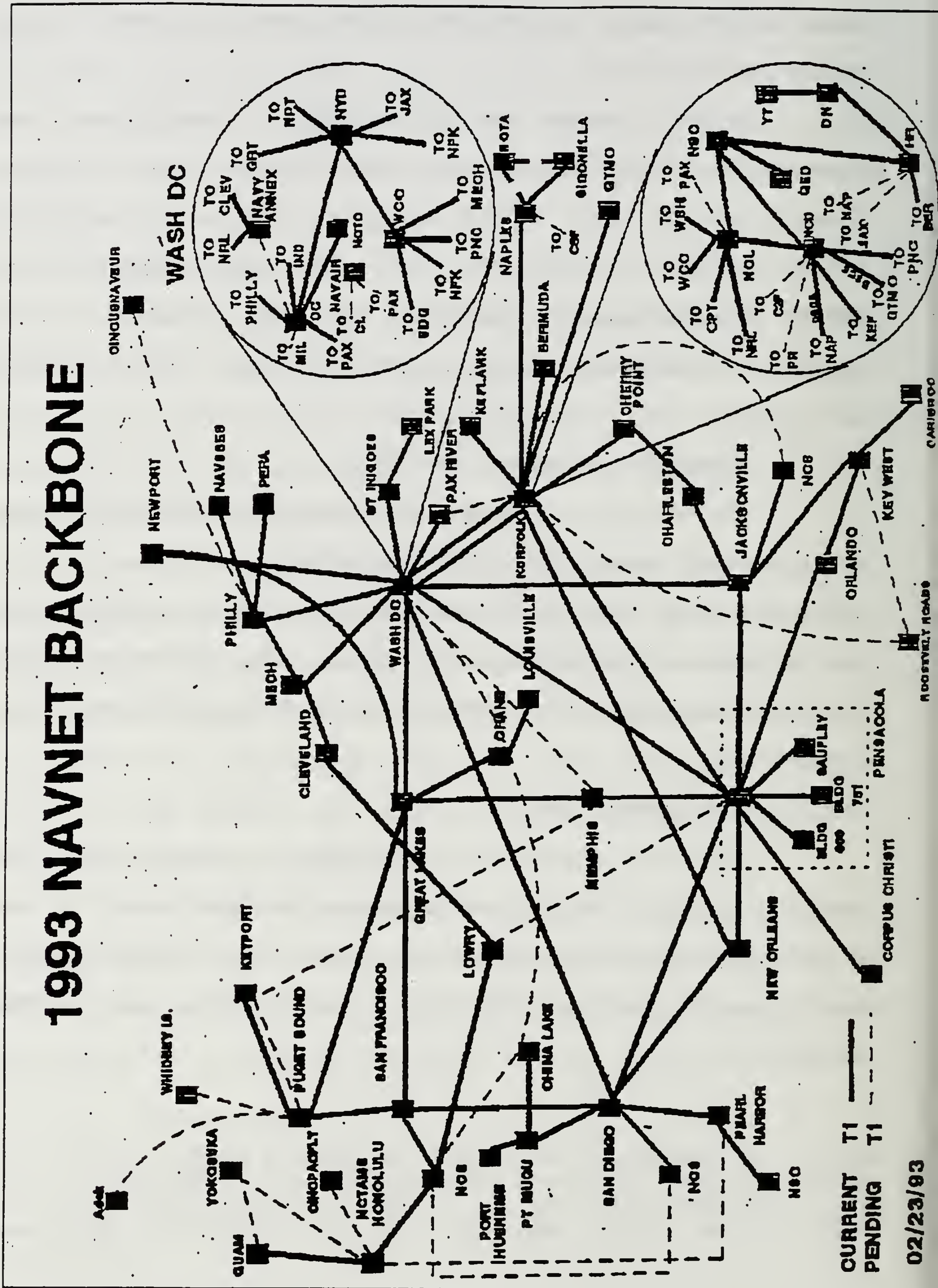

Figure 12 NAVNET Nodes [Ref. 54]

Currently, NAVNET pricing is similar to that of DCTN. NAVNET is essentially a firm-fixed, dedicated service; that is the user pays a fixed monthly fee regardless of the number of calls, distance between NAVNET VTC nodes, or the amount of connect time. This fee method generally supports high usage rates. There are no additional fees for encryption (other than the cost of supplying cryptographic devices and maintaining physical security of the equipment).

The following costs are associated with using a NAVNET line:

- (one-time) charge to connect into NAVNET (provides the user with node-to-node capability);
- (recurring) coordination fee; charge for access to NAVNET multipoint hub;
- (recurring) "tail fee;" (based on cost of running a T-1 line from the user to the nearest NAVNET node);
- (recurring) monthly line charge based on bandwidth (charge for access to the NAVNET hub).

Table IV provides sample costs associated with NAVNET video teleconferencing.

Table IV NAVNET ASSOCIATED COSTS

NAVNET COST ESTIMATES (nearest $00):
****

[NAVNET Cost Estimates do NOT include VTC equipment costs]

One-time Costs:	1st Year	Add'l Years
- Connect charge	$2,500	$0
Recurring Cost Estimates:		
- Coordination Fee ($800 / mo x 12)	$9,600	$9,600 /yr
- Monthly Line Charge (assumes no "tail-fee")		
1152 Kbps ($8,800 /mo x 12)	$105,600	$105,600 /yr
768 Kbps ($6,400 /mo x 12)	$76,800	$76,800 /yr
384 Kbps ($3,000 /mo x 12)	$36,000	$36,000 /yr

NAVNET Total Costs (1 site):

[NAVNET Cost Estimates do NOT include VTC equipment costs]

[costs do NOT include "tail-fee"]

- (user is co-located with NAVNET node)

	1st Year	Add'l Years
1152 Kbps	$117,400	$115,200 /yr
768 Kbps	$88,600	$86,400 /yr
384 Kbps	$47,800	$45,600 /yr

[Ref. 27]

NAVNET essentially affords the opportunity to use excess capacity on DCTN lines that have already been leased. Depending on the location and the excess capacity available, NAVNET might be a relatively painless and inexpensive method to provide VTC for applications that involve a substantial number of VTC hours.

VI. VIDEO TELECONFERENCING VIA SATELLITE

Satellite video teleconferencing (VTC) enjoys widescale use in DOD. Networks such as the Army Video Teletraining Network (TNET), Navy Chief of Naval Education and Training (CNET) System, Joint Worldwide Intelligence Communications System (JWICS) and the afloat Video Information Exchange System (VIXS) all employ satellites to provide VTC. Applications supported by satellite VTC include operational briefings, education and training, intelligence, telemedicine and logistics.

This chapter explains the circumstances that favor satellite VTC, describes characteristics of the system, and provides cost alternatives for using some systems.

A. CONDITIONS FOR SATELLITE VTC

For selected circumstances, satellite VTC can provide an attractive alternative to terrestrial point-to-point links. Satellite VTC is particularly attractive in any of the following situations:

- A remote location whose communications requirements do not justify the expense of installing a dedicated terrestrial (land-line or line-of-sight microwave) connection.
- A temporary location that does not afford convenient access to a terrestrial connection.

- Applications that involve frequent multipoint video connections.
- Distance learning applications where many sites are being simultaneously instructed from a central location.
- Applications that require non-preemptible service.
- Sites that approach a 100% usage rate.

The latter three items are not unique to satellite VTC. For example, non-preemptible service could be provided between two sites via a dedicated line. However, these conditions are often handled more conveniently by using satellite communications.

B. SATELLITE GEOGRAPHIC COVERAGE

Satellite geographic area coverage, also known as the "footprint," must be considered in any VTC decision. The DSCS satellite system provides virtually worldwide satellite coverage, but does not routinely provide capacity for most VTC applications. The Hughes Galaxy Satellite System advertises coverage throughout the 48 states in continental United States (CONUS), and also Alaska, Hawaii and the Caribbean basin [Ref. 55]. However, the U.S. Army TNET contract with Oklahoma State University (that uses space leased from a Hughes satellite) only provides coverage in CONUS [Ref. 56]. The AT&T TELSTAR 401 satellite, that will serve as the backbone for DCTN satellite video and the U.S. Army Satellite Education Network (SEN) when it comes on-line in the

beginning of 1994, will provide coverage throughout all fifty states, Puerto Rico and the U.S. Virgin Islands [Ref. 57].

C. SATELLITE BAND SELECTION

Most VTC applications involve frequencies in the Super High Frequency (SHF) range (between 3 and 30 Ghz) [Ref. 41: p. 2-15]. Commercial video programming is transmitted on the C and Ku satellite bands. The C band is typically 6 Ghz uplink / 4 Ghz downlink; Ku band is typically 14 Ghz uplink / 12 Ghz downlink [Ref. 18: p. 367]. Historically, educational programming used the C band. Recent educational programming favors using the Ku band because it takes up less bandwidth on the satellite transponder, and because it is less susceptible to terrestrial and microwave interference. The Ku band is more easily affected by severe rainfall than the C band. [Ref. 58] The Ku band also requires an antenna that is more accurate than one needed to receive a C band signal [Ref. 59]. An antenna designed for the more stringent Ku requirement should receive C band signals without difficulty.

D. BASIC SYSTEM COMPONENTS

A basic satellite VTC system consists of the satellite, VTC room equipment, indoor equipment to communicate with the network, a Very Small Aperture Terminal (VSAT) antenna and a

network coordination (or control) center.[27] The network control center monitors the status of all sites in the network and coordinates reservations. Figures 13 and 14 are examples of the one-way and two-way video system architectures [Ref. 60], [Ref. 36].

If codecs are used, then codec compatibility is essential. TNET ensures compatibility by using the same equipment at every site accessible to the satellite.

The DCTN satellite network employs a variation to the standard codec implementation to provide one-way only video transmission. Instead of codecs, an encode only device is provided at the broadcast site (uplink). Receive sites (downlinks) use a device that only decodes (Integrated Receiver-Decoder, or IRD). Sites can receive multiple signals simultaneously by using additional IRD boxes--one for each signal.

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[27] Videoconference room equipment includes video monitor, audio equipment, codec and peripherals for two-way video, and video monitor, audio equipment and decoder for one-way video.

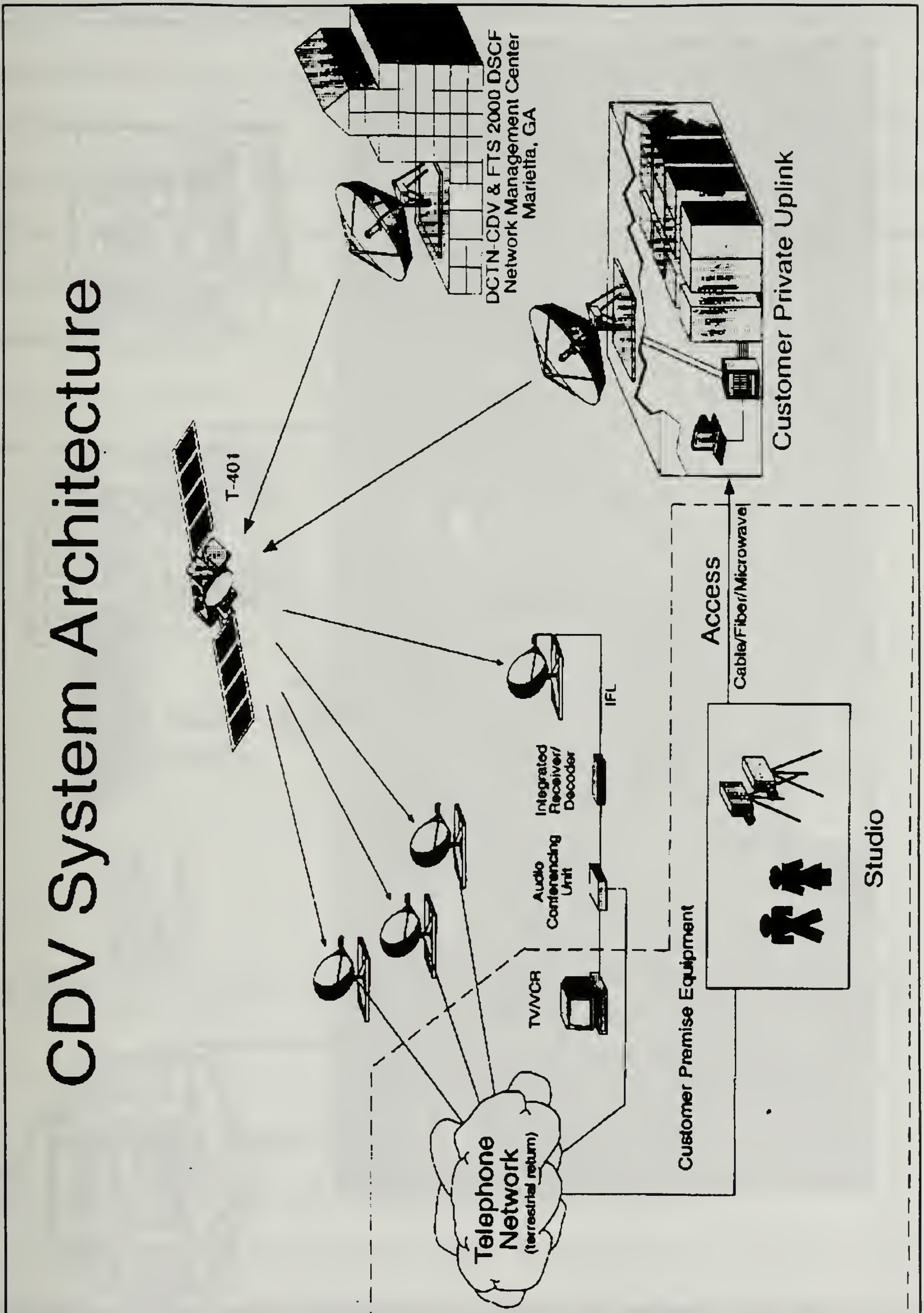

Figure 13 One-way VTC Network Configuration [Ref. 60]

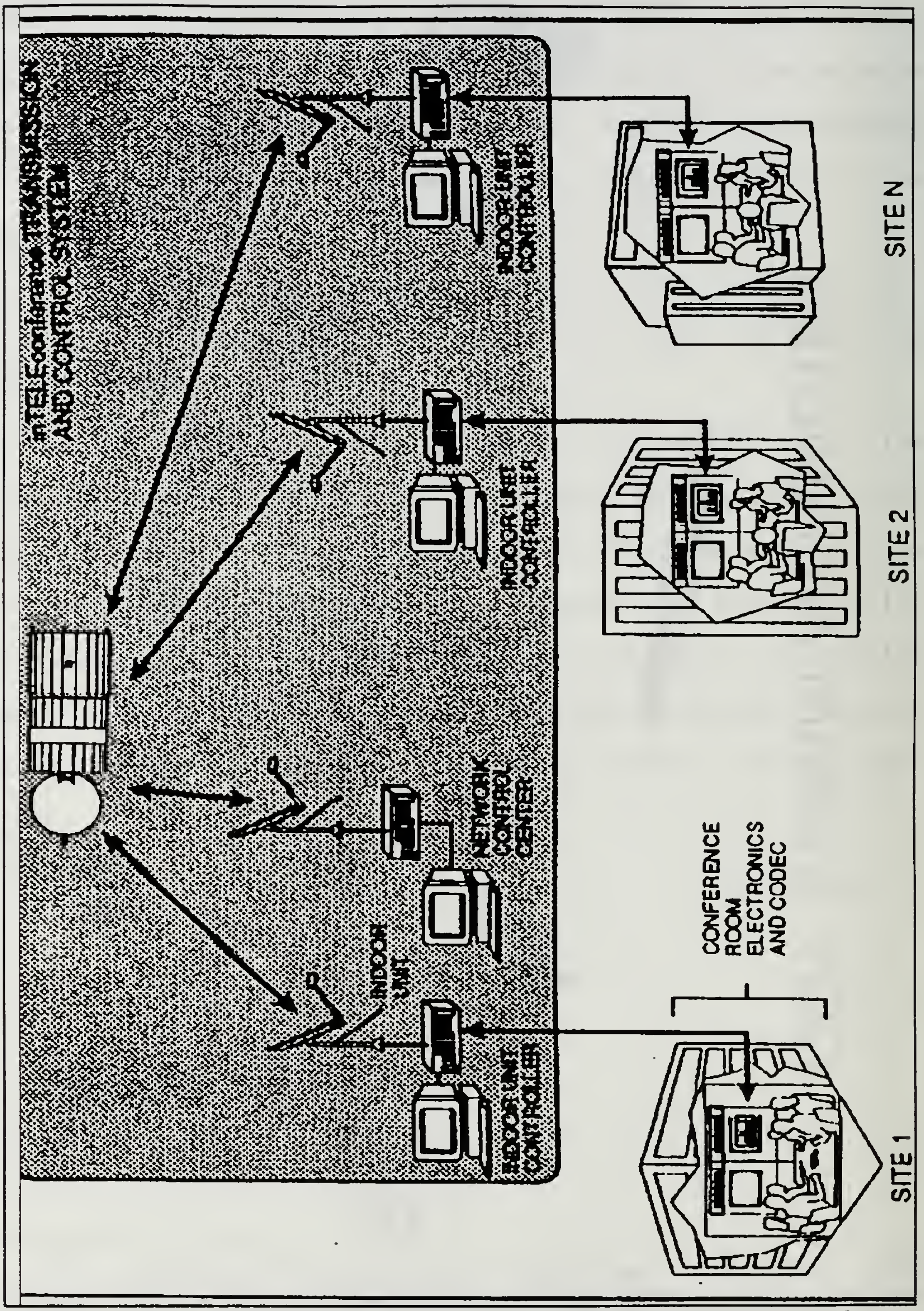

Figure 14 Two-way VTC Network Configuration [Ref. 36]

In the uplink/downlink one-way system, the video processing capability is front-loaded into the uplink. The corresponding video transmission rates of 3300 and 6600 Kbps are much greater than rates that are available using a two-way video codec. The advantage to the uplink/downlink arrangement is that after making the initial investment in the uplink, downlink sites require relatively little capital expense to join the network. Figure 15 depicts the receive site in a one-way video system architecture.

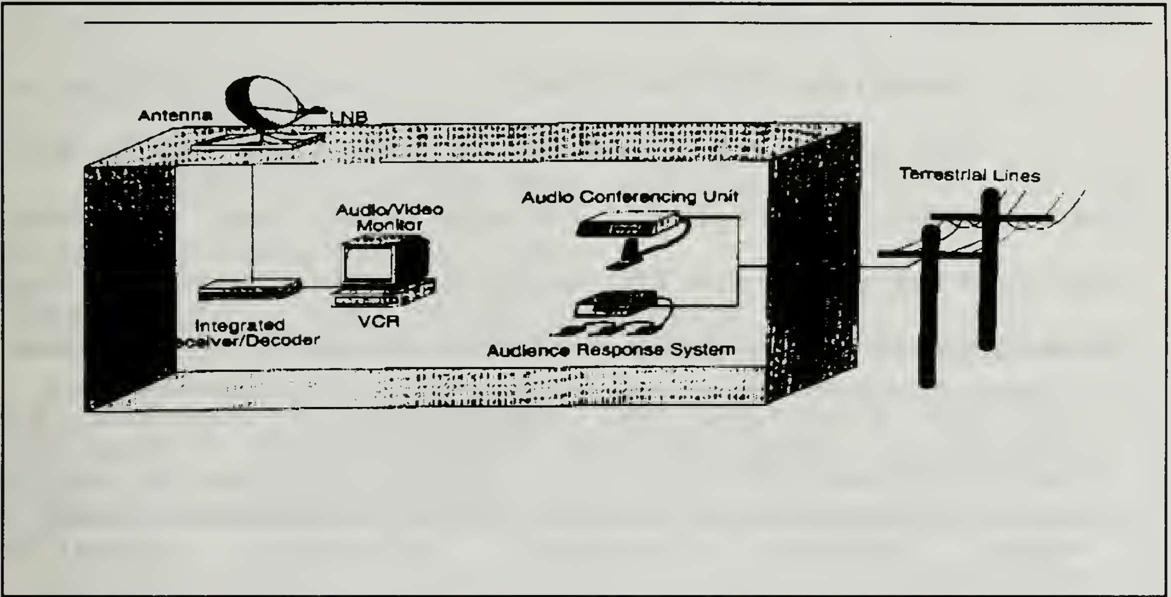

Figure 15 One-way Video, Downlink Receive Site [Ref. 60]

E. COMMERCIAL SATELLITE VTC

1. DOD Policy on Commercial Satellite VTC

Requests for a particular VTC capability ordinarily go through DISA in accordance with the Office of the Assistant

Secretary of Defense memorandum on "Department of Defense (DOD) Policy for Videoteleconferencing (VTC) Management, Acquisition, and Standards," dated 26 October, 1993 (the "Castleman Memorandum"). Approved requirements that justify a satellite-based solution will be forwarded to the Defense Commercial Contracting Office (DECCO) who will procure the desired service (for a two percent fee of the eventual contract award). The current DCTN contract to support satellite VTC was approved by DECCO in August 1993. [Ref. 61][28]

2. Satellite VTC Via DCTN

The Air Force Institute of Technology (AFIT) and the Army Logistics Management College (ALMC) are examples for implementing satellite VTC using the DCTN Compressed Digital Video Service (DCTN-CDV).

> DCTN-CDV digitizes and compresses a standard NTSC television signal from the equivalent of 90 Mbps to a user-selected 3.3 Mbps or 6.6 Mbps. A DCTN-CDV network may be deployed for Very Small Aperture Terminal (VSAT) or Micro Aperture Terminal (Microsat) operation. [Ref. 62]

DCTN satellite service is only contractually available during business hours. This is primarily due to the absence of any articulated requirement for service during other times [Ref. 61].

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[28] DCTN satellite VTC is technically video teleseminar (one-way video) in virtually all cases.

The DCTN satellite implementation is designed to support a one-way video, two-way audio topology. Although it theoretically could support two-way VTC, the equipment costs for this specific implementation are prohibitive.[29]

The initial uplink cost constitutes the largest portion of the DCTN satellite video expense. Factors affecting the purchase include the following:

- number of channels required at the time of installation;
- potential total channel capacity (number of channels anticipated over the life of the system); and
- required system reliability.

Capability differences between the AFIT and ALMC systems are summarized in Table V.

Table V AFIT - ALMC UPLINK COMPARISON

	# of Channels Initially Installed	Potential # of Channels	Reliability
AFIT	3	6	99.5%
ALMC	2	2	99.0%

[Ref. 61]

[29] Cost for a single channel, two-way video uplink is over $300,000. All two-way video sites would have to purchase this equipment and it would not be compatible with the one-way video models.

The ALMC uplink provides for simultaneous broadcasts on two channels; it cannot be upgraded to accommodate additional channels. The AFIT uplink currently accommodates simultaneous broadcasts on up to three different channels from the single uplink site; this system can be upgraded to include as many as six channels. This means that up to six different programs or courses could be simultaneously transmitted to any number of receive sites. The capital outlay for this increased broadcast capability is formidable--slightly over a million dollars. [Ref. 63]

DCTN satellite VTC costs for a single channel are described in Table VI. Note that costs for DCTN satellite usage are computed differently than those associated with the TNET system. TNET costs are fixed, independent of usage. DCTN satellite costs are usage-sensitive; Satellite Time (or transmission) costs are applied for each hour of actual use. However, the usage-sensitive costs are the same whether the transmission goes to one site or to 1,000 sites (virtually any number of sites can be accommodated as long as the sites are physically located within the satellite "footprint"). VTC - use cost ranges between $200 per hour and $350 per hour, depending on the amount of hours used in any month (higher use yields lower costs per hour). Tables VI and VII provide an example of DCTN Satellite VTC costs.

Table VI SATELLITE UPLINK COSTS (PURCHASE OPTION)

UPLINK COSTS (nearest $00):

****

One-time Costs:	1st Year	Years 2 - 12
- Equipment[1] (redundant/no-upgrade)	$320,000	$0
- Site Survey	$8,400	$0
Recurring Costs:		
- Maintenance (1 Channel)[2] ($2,567/month x 12 months)	$30,800	$30,800 / yr
- Network Management ($900/month x 12 months)	$10,800	$10,800 / yr
- Satellite Time (1 Channel)[3]		
(288 hours)[4, 5]	$100,800	$100,800 / yr
(2196 hours)[6]	$439,200	$439,200 / yr
Uplink Total Costs (288 hrs):	$470,800	$142,400
Uplink Total Costs (2196 hrs):	$809,200	$480,800

DOWNLINK COSTS (nearest $00):

****

One-time Costs (per site):	1st Year	Years 2 - 12
- Equipment (1.2 m antenna)[7, 8]	$7,400	$0
- Site Survey	$500	$0
Recurring Costs:		
- Maintenance/Management ($71/month x 12 months)	$900	$900 /yr
- Audio portion[9]	(variable)	(variable)
Downlink Total Costs (1 site):[10]	$8,800	$900 /yr

[1] While this is technically the capitalized amount of lease charges (with an unspecified option for purchase), DECCO is currently negotiating with AT&T to have this become the actual purchase price.

[2] Additional channels at $1,100/month.

[3] Satellite rate depends on the actual hours used by each channel.

[4] Based on 24 hrs/month ($350/hr); no discount rate applies.

[5] Note that increased hours do not linearly increase costs, due to the discount pricing.

[6] Based on 183 hrs/month ($200/hr); includes 25% discount rate.

[7] Some locations require a larger antenna ($5k additional)

[8] Downlink costs do not include video monitors.

[9] Depends on long-distance service used.

[10] Some locations require a larger antenna ($5k additional)

[Ref. 61], [Ref. 64]

Table VII ADDITIONAL UPLINK SITE PURCHASE OPTIONS

UPLINK EQUIPMENT COSTS (figures to the nearest $100):

["Redundant" systems include duplicate hardware that provides redundancy in event of any single component failure; reliability rate = 99.5%.]

["Non-redundant" systems are susceptible to down-time from single component failures with repair within two days of failure; reliability rate = 99%.]

	Redundant	Non-Redundant
6 Channel Capable System. - With 1 video channel at time of purchase:	$1,257,400	$939,300
2 Channel Capable System. - With 1 video channel at time of purchase:	$1,072,900	$879,400
1 Channel Capable System. - With 1 video channel at time of purchase:	$589,400	$352,000
Additional Video Channels. - At time of purchase:	$131,600 ea	(N/A)
- As eventual upgrades	$155,700 ea	(N/A)

[Ref. 64]

3. Satellite VTC Via TNET

An alternative method to obtain satellite VTC was used by the Army Training and Doctrine Command (TRADOC), who were able to generate a solicitation to lease audio-visual services. TNET has a five year contract (through July 1995)

with Oklahoma State University to provide leased satellite VTC equipment and services.

TNET is the largest fully interactive video training network in the world [Ref. 65]. In 1992, TNET won the "Teleconference Magazine" award for the "Most Significant Advance in Distance Learning Overall." The award was earned for language training provided by the Defense Language Institute (DLI) to troops preparing for Desert Storm. [Ref. 66]

The foundation for TNET is the Hughes SBS-5 satellite. The video signal is digitized, compressed and transmitted in the Ku band using time division multiple access (TDMA) [Ref. 67], [Ref. 68]. Figure 16 depicts the basic remote site in the two-way video architecture.

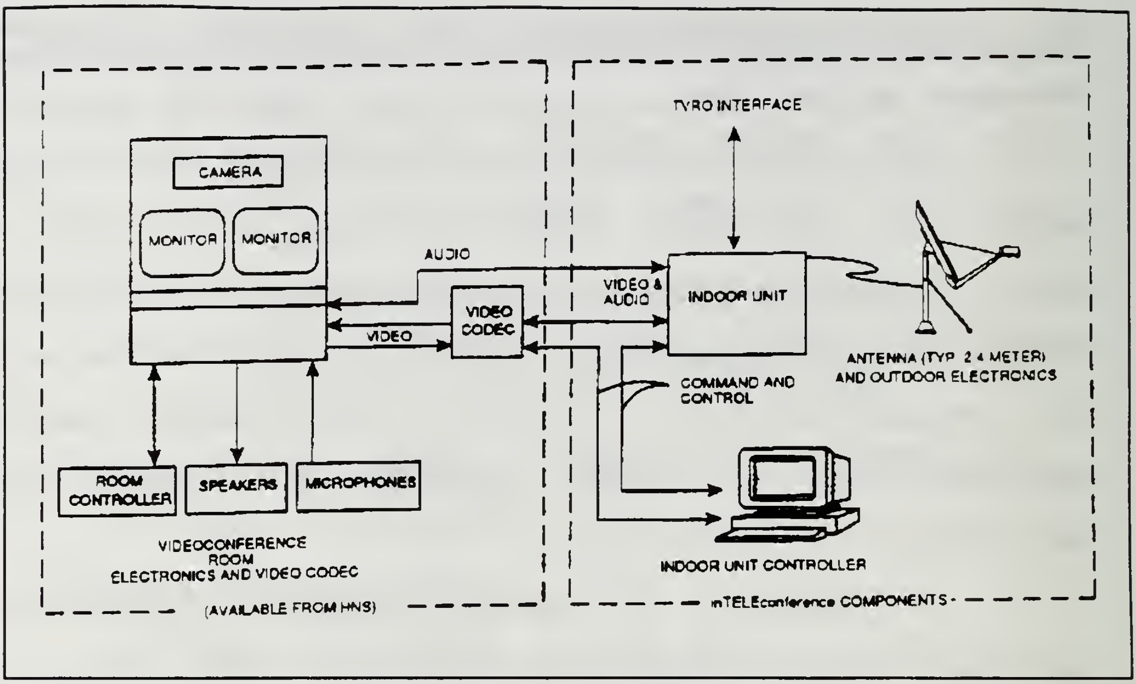

Figure 16 Two-way VTC Remote Site [Ref. 36].

By exercising a technology refreshment clause in their contract with Oklahoma State University, TNET recently switched from the CLI-based Rembrandt II to a system based on the VTel BK-235. A detailed list of the current TNET standard VTC suite is provided in Appendix D.

Tables VIII and IX provide a summary of the costs associated with the TNET contract. Requests for equipment under the TNET contract are coordinated by the Army TRADOC contracting activity. Approximately 120 Army and Air Force sites will receive this equipment in 1994 [Ref. 69]. The Army advertises site set-ups typically less than 60 days after they receive the order [Ref. 68]. Services under this contract are available to any DOD Agency.

Table VIII TNET VTC COSTS

- Equipment (1st year)	$96,000	(one-time cost includes site survey, installation and delivery, and future de-installation; annual costs cover equipment, maintenance and network management)
(Years 2-5)	$76,000 /yr	
Satellite Time	$55,000 /yr	
Total Costs: (1st year)	$151,000	
(Years 2-5)	$131,000 /yr	
Additional Options:		
- Quick Frame Card	$9,500	(increase smoothness of the picture)
- VCR option	$1,800	($150 / month)

[Ref. 56]

Table IX TNET VTC MISCELLANEOUS NOTES/FEATURES

Miscellaneous Notes/Features:

- Uses VTEL BK-235 Codec at speeds up to 384 kbps.
- Non-preemptive, 24-hour programming.
- Multi-point two-way VTC between 1 to 16 sites.
- A single space segment is the minimum required to support VTC between 16 sites.
- Supports 2-way audio, video and interactive graphics between all sites.

- Costs to relocate the equipment after installation are as follows:

  Short-distance (on-base) move.
  Satellite contract technician: $1,800/day
  (2 day minimum)
  (assumes govt. personnel and equipment are provided to assist)

  Long-distance move.
  Equipment de-installation: $6,800
  Equipment re-installation: $6,000
  Transportation: $1,500 +
  (depends on distance)

[Ref. 56]

F. DSCS SATELLITE VTC

The Defense Satellite Communications System (DSCS) Network links components to support functions such as tactical voice communications, remote data base access, air tasking orders and imagery distribution [Ref. 70]. The foundation of DSCS is a collection of satellites that provides practically worldwide SHF satellite coverage.

The active constellation includes two DSCS II satellites, positioned over the Western Pacific and Indian Ocean, and

three DSCS III satellites operating over the Eastern Pacific, Western Atlantic, and Eastern Atlantic plus three reserve satellites. [Ref. 41: p. 6-24]

DSCS reception has been evaluated as poor in the higher latitudes (at the edge of the "footprint") [Ref. 71]. DSCS was recently used to support VTC by providing the ship to shore connection during Exercise Tandem Thrust '93 (held in late summer, 1993) [Ref. 72].

1. DOD Policy on DSCS Satellite VTC

Satellite availability is requirements based. Bandwidth requirements from all of the Armed Services are reviewed and prioritized according to guidelines described in Joint Staff Memorandum of Policy 37 (MOP 37). DSCS was a "mature system" in 1991 that was "nearly saturated with traffic, as measured in either bandwidth or power consumption [Ref. 41: p. 6-24]. Due to the high traffic level of traffic, satellite time is a scarce commodity. The following traffic allocations were projected for DSCS for the mid- 1990s:

DSCS User	Projected Allocation
Intelligence Community	23.8%
Ground Mobile Force Community	21.4%
CINCs/Services dedicated communications	14.1%
Defense Dissemination System	11.6%
Air Force Satellite Control Network	11.5%
Diplomatic Telecommunications Service	9.4%
Defense Communications System	8.2%

[Ref. 41: p. 6-24]

After the requirements are reviewed and prioritized, each service is provided a sub-allocation of bandwidth. VTC can

occur using DSCS, but only if they successfully compete against existing service applications. Typically, no special or additional bandwidth is allocated in any Service sub-allocation specifically for VTC. When VTC becomes a high enough priority, the individual service will temporarily re-prioritize its requirements to make room for the VTC. As an example, for VTC to occur during a CINC- sponsored exercise, bandwidth required for the VTC must be taken from other circuits. The operational commander must make the decision that the VTC is important enough to justify preempting the other circuits for the duration of the VTC.

2. DSCS VTC Costs

There is no financial cost referred back to the user for employing a DSCS satellite in VTC. The only realized "cost" (as previously discussed) is the lost capability from circuits that were preempted to provide adequate bandwidth for the VTC. It is illuminative to note that the shipboard installation to support VTC runs in the neighborhood of $100,000 (comparable to a shoreside VTC effort that requires extraordinary installation and development costs). This figure is roughly double the cost of similarly outfitting a shoreside VTC room that requires no extraordinary preparation (i.e.,transmission lines are already in-place at the facility).

G. SATELLITE VTC VIA FTS2000

There is no current capability for using satellite VTC within the FTS2000 "A" Network contract (serviced by AT&T). However, a recent proposal to upgrade the FTS2000 contract includes the capability for a wideband service. This service would use digital satellite compression techniques to provide near full-motion video quality at a 3.3 Mbps data rate. The service, if approved, would be available to anyone on the FTS2000 "A" Network and would include coverage throughout all fifty states, and parts of the Caribbean. [Ref. 73]

The FTS2000 "B" Network (Sprint) is currently providing a wideband video satellite service under a beta test with the Internal Revenue Service (IRS). "IRS University" uses a one-way video and two-way audio topology that allows students to see the training presentation and then call-in the instructor with their questions. IRS is presently the only bureau using both compressed video and wideband service on FTS2000. [Ref. 74]

VII. VIDEO TELECONFERENCING ON FTS2000

A. FTS2000 BACKGROUND

Federal Telecommunications System 2000 (FTS2000) was established in December 1988 to provide long-haul communications for all government agencies. FTS2000 is managed by the General Services Administration (GSA), and consists of two major contracts that divide communications services into an "A" Network serviced by AT&T, and a "B" Network serviced by Sprint. GSA is the entity that actually assigns specific agencies to either the "A" or "B" networks [Ref. 75].

FTS2000 provides the following basic types of services:

- Switched Voice Service for transmitting voice and data at rates up to 4.8 Kbps,
- Switched Data Service for dialed-up end-to-end digital data transmission at 56 Kbps and 64 Kbps,
- Video Transmission Service for compressed video and full motion teleconferencing,
- Packet Switched Service for transmitting data in packet format,
- Dedicated Transmission Service for point-to-point private line service from voice grade analog up to 1.544 Mbps, and
- Switched Digital Integrated Service (SDIS) for a combination of services using T-1 or Integrated Services Digital Network (ISDN). [Ref. 41: p. 6-34]

FTS2000 was intended to last 10 years and has survived occasional congressional challenges to find alternatives. The FTS2000 contracts are due to expire in December, 1998 [Ref. 76].

B. FTS2000 INFRASTRUCTURE

The FTS2000 backbone consists of service nodes (switches) that are interconnected by T-3 (44.7 Mbps) fiber-optic links. Users access FTS2000 via Service Delivery Points (SDP's) located (usually) at the customer's premises.[30] The interfaces that provide access to FTS2000 can be private branch exchanges (PBXs), or other customer-owned equipment. [Ref. 41: p. 6-34] Specific VTC capability on FTS2000 will be described in later sections.

C. REGULATIONS REGARDING FTS2000 USE

A federal agency with a requirement for point-to-point or multipoint video teleconferencing (VTC) at 384 Kbps is normally required to use FTS2000. A requirement for VTC using variable bandwidths, as well as Warner Exempt requirements,

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[30] Service Delivery Points (SDP's) are points of demarcation that separate the portion of the communications connection serviced by FTS2000 from the portion serviced by the local communications infrastructure (i.e. the phone lines that are on base).

can be excluded from the FTS2000 mandatory use provision by obtaining a waiver from GSA. [Ref. 77][31]

D. VIDEO TELECONFERENCING ON THE "A" NETWORK (CVTS)

1. "A" Network VTC Capability

Network "A" is the 60 percent portion of the FTS2000 contract that is handled by AT&T. VTC capability depends on the features that AT&T makes available to the FTS2000 contract.

Network "A" CVTS operates exclusively at 384 Kbps, and provides both point-to-point and "Dynamic Multipoint (DMP) selections for VTC."[32] "Dynamic Multipoint" presents three modes:

- Chairperson Control Mode -- chairperson designates the site that will be seen by all other sites;
- Voice Activated Switching -- video automatically switches to the broadcast site with the largest audio level;
- Lecture Control Mode -- chairperson selects the broadcast site and the video that the broadcast site will see. [Ref. 78]

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[31] The variable bandwidth example might be a site that, for different sessions, requires VTC at speeds of 384 Kbps for one site, and 768 Kbps for a second site.

[32] "Dynamic Multipoint" is a slight variation from "Selective Presence Multi-point" VTC as described in Chapter II. "Dynamic Multipoint" is similar to the DCTN "Interactive Multipoint" in that it only allows one site to be seen during the multi-point VTC.

The maximum number of sites in an "A" Network CVTS multipoint conference is 14 (including the originator and 13 additional sites).[33] An upgrade is expected to increase this capability to a maximum of 22 sites. [Ref. 77]

Video teleconferencing using CVTS is reservation based. Conference times are available 24 hours a day and can be scheduled with as little as 30 minutes notice, or up to a year in advance [Ref. 78]. Conferences can be guaranteed by scheduling 24 hours in advance [Ref. 77].

2. "A" Network Equipment Required For VTC

The "A" Network furnishes the codecs and the transmission lines. Customers must provide the VTC room and associated video equipment other than the codec. FTS2000 requires that the codecs be provided as part of the CVTS service. The only codecs available for CVTS video teleconferencing are the Compression Labs Inc. (CLI) Rembrandt II/02 or the Rembrandt II/VP. Customers who already have codecs must obtain a waiver from GSA to use the equipment with CVTS.

Customers with secure VTC requirements must provide their own encryption devices and ensure the security of the VTC equipment.

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[33] A single "A" Network site could conceivably connect to 31 additional sites during a VTC with sites on the AT&T Global Business Video Services (GBVS) Network.

The "A" Network has direct access via gateways in Vienna, Virginia, to the following networks:

- AT&T Global Business Video Services (GBVS), and
- Sprint Meeting Channel.

The "A" Network is expected to provide direct access to the "B" Network sometime during the Summer, 1994. There are no current plans for the "A" Network to directly access DCTN. However, interoperability is possible by connecting from the "A" Network through the Sprint Meeting Channel to the AT&T Accunet gateway into DCTN. [Ref. 77]

3. "A" Network VTC Costs

The costs for VTC on the "A" Network include both fixed and variable components. The variable portion is determined by the following aspects:

- actual usage -- depends on distance and location, and is based on minutes per month;
- type of conference -- point-to-point or "Dynamic Multipoint;"
- FTS2000 level of service -- "Access Type"

The following list summarizes costs associated with VTC using CVTS on the "A" Network:

- (one-time) connect charge;
- (recurring) monthly codec fee;

- (recurring) "Service Ready Availability" charge (monthly network coordination fee);
- (each use) conference establishment charge for each location;
- (each use) variable line cost based on actual usage and level of service;
- (each use) (optional) encryption charge for each location. [Ref. 78]

Note that there is no associated "tail fee," because the user must already be connected to FTS2000. Tables X and XI provide sample costs associated with FTS2000 CVTS video teleconferencing.

Table X FTS2000 CVTS VTC COSTS

FTS2000 CVTS COST ESTIMATES (nearest $00):

****

[CVTS Cost Estimates do NOT include VTC equipment costs other than the codec]

One-time Costs:	1st Year	Add'l Years
- Network connect charge	$2,500	$0
Recurring Cost Estimates:		
- Monthly codec fee ($800 / mo x 12)	$7,200	$7,200 / yr
- Service Ready Availability ($520 / mo x 12)	$6,200	$6,200 / yr
- Variable Monthly Usage Costs	(usage)	(usage)

[CVTS Cost Estimates do NOT include VTC equipment costs other than the codec]

[Ref. 78]

Table XI SAMPLE FTS2000 CVTS COST CALCULATIONS

SAMPLE CALCULATIONS FOR VARIABLE MONTHLY USAGE COSTS:
(Following costs apply for each **1-hour** session)

- Conference Establishment Charges

Point-to-Point	$15 / site
Dynamic Multipoint	
Originator	$15 / one site
Non-originator	$57 / site

- (Optional) Encryption $25 / site

CITY PAIRS	SDIS Access	Non-SDIS Access
Wash,DC - San Fran, CA	$110	$126
Wash,DC - Chicago, IL	$110	$126
Wash,DC - Atlanta, GA	$108	$123
Wash,DC - Denver, CO	$108	$123
Wash,DC - Baltimore, MD	$75	$91

Point-to-Point rate (Wash,DC - San Fran, CA)	$126	$110
Dynamic Multipoint rates for all locations above:	$339	$384
Conference Establishment Charges (1 x 15 + 5 x 57)	$300	$300
	=====	=====
Total:	$639	$684

[Ref. 78]

E. FTS2000 "FRACTIONAL T-1" FOR VTC

The alternative for VTC on the "A" Network is to use either a full T-1 or a "fractional T-1" service.[34], [35] This arrangement merely provides the transmission medium while the user must provide all of the VTC equipment.

There is an important consideration for comparing FTS2000 "fractional T-1" service with DOD common-user networks (i.e., DCTN, NAVNET, etc.) The DOD common-user networks already include infrastructure links (such as hubs and switches) tailored to support their networks. FTS2000 "fractional T-1" service might require additional circuits to provide specific connections between sites. This is logically no different than the DOD common-user networks. However, the DOD common-user networks (in many cases) already have the desired connections in place.

The following costs apply for CVTS using full T-1 and "fractional T-1" service on FTS2000:

- (one-time) service initiation charge (one for each end of the circuit);

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[34] "Fractional T-1" refers to using, and subsequently only being charged for, a fraction of the bandwidth available on a 1.544 Mbps T-1 line. "Fractional T-1" speeds are usually measured in quarter increments (i.e. 768 Kbps is one-half of a T-1 line; 384 Kbps is one-fourth; etc.)

[35] Network "A" is developing wideband video transmission service comparable to the DCTN satellite service discussed in Chapter VI. However, since (like DCTN) this service is one-way only, it will not be included in this VTC discussion.

- (each use) origination and termination charge based on destination and level of service;

- (each use) line (data transport) cost based on bandwidth, destination and level of service.

Table XII provides sample costs associated with using FTS2000 "fractional T-1" service. Keep in mind that these costs are only valid between two sites.

Costs for additional sites for the purpose of multipoint VTC are more difficult to compute. The additional monthly line charge is relatively straightforward and is the charge of the additional line (roughly based on distance). The problem begins with establishing the circuits in a multipoint arrangement. This will require introducing some type of multipoint control unit to coordinate communications between all sites. Multipoint control units that can accommodate up to 16 ports are priced in the neighborhood of around $95,000.[36] DOD common-user networks typically have already furnished this infrastructure investment.

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[36] Estimate from GSA prices in effect as of February, 1994 for VTEL and PictureTel multipoint control units.

Table XII FTS2000 "FRACTIONAL T-1" COSTS

FTS2000 "FRACTIONAL T-1" COST ESTIMATES (nearest $00):

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[Cost Estimates do NOT include VTC equipment costs]

One-time Costs:		1st Year	Add'l Years
- Service Initiation		$4,000	$0

Recurring Cost Estimates:

- Monthly Line Charge (non-SDIS)

(Monterey, California to Washington, D.C.)			
T-1	($7,429 /mo x 12)	$89,100	$89,100 / yr
768 Kbps	($5,130 /mo x 12)	$61,600	$61,600 / yr
384 Kbps	($3,378 /mo x 12)	$40,500	$40,500 / yr

(Monterey, California to , Camp H.M. Smith, Hawaii)			
T-1	($9,064 /mo x 12)	$108,800	$108,800 / yr
768 Kbps	($8,250 /mo x 12)	$99,000	$99,000 / yr
384 Kbps	($5,358 /mo x 12)	$64,300	$64,300 / yr

===

"Fractional T-1" Total Costs (between 2 sites):

[Cost Estimates do NOT include VTC equipment costs]

(Monterey, California to Washington, D.C.)		
T-1	$93,100	$89,100 / yr
768 Kbps	$65,600	$61,600 / yr
384 Kbps	$44,500	$40,500 / yr

(Monterey, California to , Camp H.M. Smith, Hawaii)		
T-1	$112,800	$108,800 / yr
768 Kbps	$103,000	$99,000 / yr
384 Kbps	$68,300	$64,300 / yr

(Prices are slightly less in all categories for Switched Digital Integrated Service (SDIS))

("Fractional T-1" is available at speeds of 128-768 Kbps in increments of 64 Kbps).

[1] Charge is $2,000 for each end of the circuit.

[Ref. 79]

F. VIDEO TELECONFERENCING ON THE "B" NETWORK

1. "B" Network VTC Capability

The "B" Network refers to the 40 percent of the FTS2000 contract that is handled by Sprint. Although this network has historically used 768 Kbps as its VTC speed, on 31 December 1993, the "B" network began exclusively using 384 Kbps for its Compressed Video Transmission Service (CVTS). This speed change occurred to facilitate interoperability with the "A" Network. [Ref. 80]

The other alternative for VTC on the "B" Network is to use dedicated T-1 service.[37] "Fractional T-1" service is in beta test, but is not yet available as an FTS2000 service on the "B" Network.

While the Sprint Meeting Channel provides multipoint capability, the "B" Network currently only provides point-to-point VTC [Ref. 81].

Video teleconferencing using CVTS is reservation based. Conferences are subject to availability. However, conferences can be scheduled with as little advance notice as 24 hours.

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[37] Network "B" does offer wideband video transmission service comparable to the DCTN satellite service discussed in Chapter V. However, since (like DCTN) this service is one-way only, it will not be included in this VTC discussion.

The "B" Network has access to other networks, including DCTN and AT&T Accunet, through a gateway to the Sprint Meeting Channel.

2. "B" Network Equipment Required For VTC

"B" Network VTC is similar to the "A" Network in that the CVTS is a codec to codec service. Sprint provides the codecs and the transmission lines; users provide the room and the additional VTC equipment.

The codecs provided with CVTS are Compression Labs Inc. (CLI) Rembrandt models. However, the "B" Network also offers a "Beta Test Option" that allows users to test their equipment for FTS2000 compatibility. [Ref. 82]

3. "B" Network VTC Costs

CVTS costs include both fixed and variable, usage-based cost components. The following costs are associated with using CVTS on the "B" Network:

- (one-time) service initiation fee;
- (recurring) monthly CVTS fee;
- (each use) call initiation plus origination and termination fees;
- (each use) usage fees per conference; variable based on number of locations in a conference, distance between conference locations and the overall volume of calls at the site (or Service Delivery Point--SDP) for the month.

While the exact rates are usage and distance dependent, an estimate for a point-to-point VTC from Washington D.C. is

between $81 (local to Virginia) and $96 (long-distance to Los Angeles, California) for a 30 minute session using the 384 Kbps CVTS [Ref. 81].

FTS2000 "B" Network costs are slightly less than comparable costs for the Sprint Meeting Channel [Ref. 83].

VIII. CONCLUSIONS

This thesis has described several different methods for video teleconferencing (VTC) that are in use in DOD. Figure 17 provides a comparison of operational characteristics for each method.

While NAVNET does not offer a different method, it is illustrative of a common-user network alternative for VTC. The Chief of Naval Education and Training (CNET) Electronic Schoolhouse Network (CESN) has been included because it is a kind of hybrid; it uses equipment similar to TNET, but is connected using terrestrial vice satellite links. Also, CESN will operate using FTS2000 dedicated lines beginning in April 1994. The Satellite Education Network (SEN) is included to represent a DCTN satellite application (one-way video teleseminar) to contrast the VTC methods.

Cost comparisons are not so straightforward. Equipment and capability variations between VTC methods preclude exhaustive cost comparisons (i.e., it is difficult to place a comparative worth on the value of the TNET training system that is included in the VTC contract). Additionally, cost estimates that use usage-sensitive or distance-sensitive pricing will vary for different locations and levels of use. Cost estimates must be developed with specific locations and usage rates known in advance in order to provide meaningful

NETWORK COMPARISON CHART

	Contract expires	Two-way Video and Audio	Max # of multipoint sites	Available speeds (Kbps)	Most common speed	Most common codec	Encryption Device	Usage-Sensitive	Distance-Sensitive	Guaranteed Access
DCTN	Mar '96	Yes	25	56 - 1408	Depends	CLI	KG-194	No	No[1]	Yes - 1 hr advance
NAVNET	Mar '96	Yes	16	56 - 1152	384	PictureTel	KG-194, 84	No	No[1]	No - 24 hr advance
FTS2000										
CVTS	Dec '98	Yes	14	384	384	CLI	Depends	Yes	Yes	Yes - 24 hr advance
Dedicated	Dec '98	Yes	14[2]	56 - 1544	Depends	(Any)	Depends	No	Yes	Yes
CESN	Dec '98	Yes	14	384	384	VTEL	KG-194, 81	No	No	Yes
TNET	Jul '95	Yes	16[3]	384	384	VTEL	None[4]	No	No	No - 1 hr advance
SEN[5]	Mar '96	No	Infinite	3300 - 6600	3300	N/A	DES	Yes	No	Yes - 30 days advance

Notes:

1. Any "tail fee" is distance-sensitive from the nearest node.
2. Depends on multipoint control unit between links
3. Up to 40 sites in one-way broadcast mode.
4. KG devices are compatible but are not used.
5. Tariff service is only 6AM - 6PM, Eastern Time.

Figure 17 VTC Network Comparison

analysis. Despite the obstacles, it is possible to present some limited general cost comparisons.

A. COMPARISON OF DEDICATED NETWORKS

Without addressing specific network advantages and disadvantages, Figure 18 depicts sample annual costs associated with a dedicated 384 Kbps connection between the West Coast and the East Coast.[38] The comparison does not include costs related to establishing the initial connection.

Costs for both NAVNET and DCTN (except for the "tail" site) reflect sites located at network nodes. Sites located farther from the nodes will incur higher costs. NAVNET sites near nodes are more economical than some DCTN connections that require a "tail."

FTS2000 is the least cost alternative for dedicated point-to-point VTC. However, the comparison does not apply for a multipoint arrangement. Every method indicated except for FTS2000 includes an investment in multipoint control units that permit multipoint VTC.

The indicated TNET cost includes only the portion associated with satellite transmission. Although TNET appears to experience the highest operational costs, the impression is somewhat misleading. The actual TNET contract combines both

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[38] The comparison (excepting the "tail" example) uses sites that reflect low cost connections for the particular network. The West Coast and East Coast locations are not necessarily the same for each network.

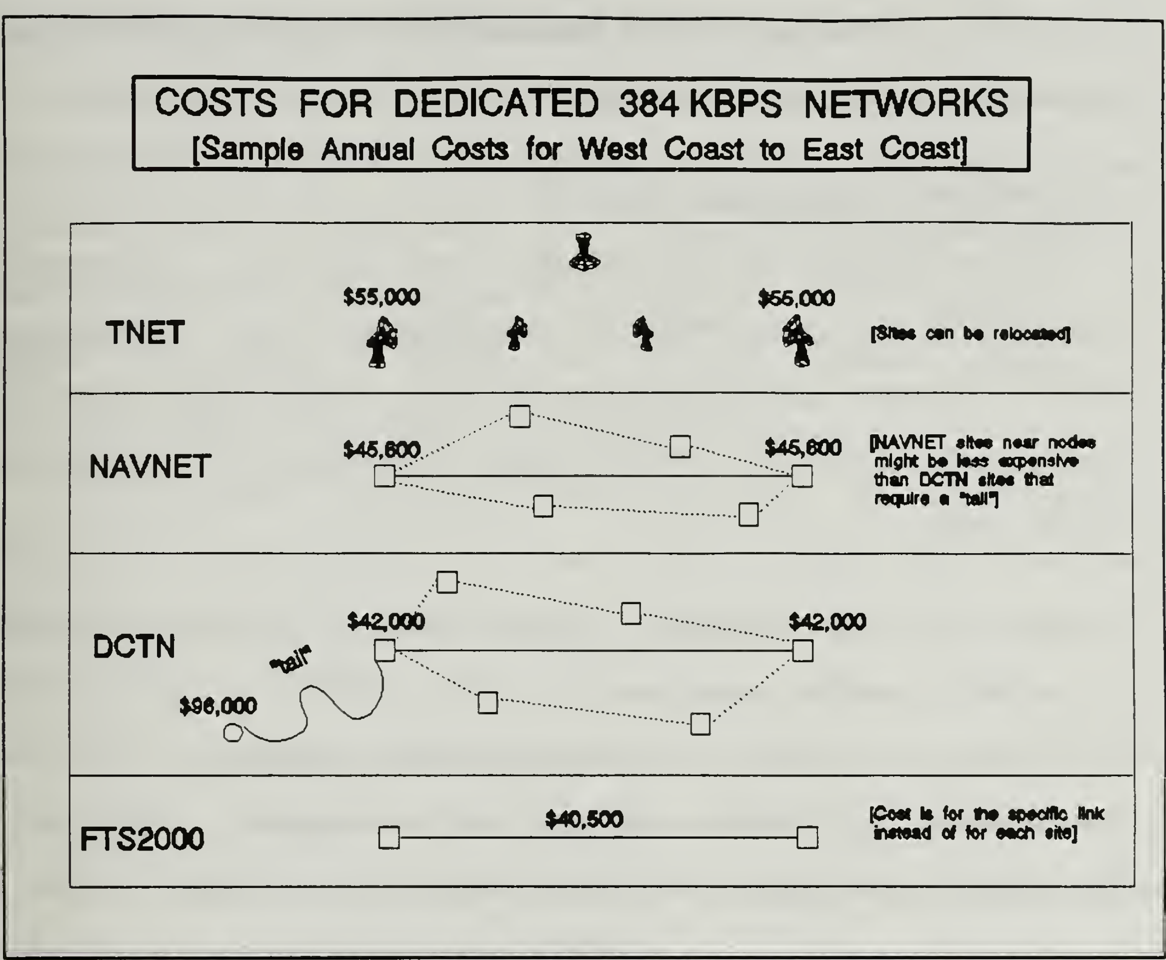

Figure 18 Comparison of Dedicated Lines at 384 Kbps

transmission services and VTC equipment to form an entire training system. Connection to TNET includes instant equipment compatibility in a pre-arranged format designed to support distance learning. The Army is satisfied with the format.

It is interesting to note that the VTEL equipment used for TNET can also be used over terrestrial links. Where terrestrial links are in place, TNET could theoretically reduce operational costs by communicating via landlines vice

satellite. However, using terrestrial links is not an option included in the TNET contract.

B. CVTS VS. DEDICATED SERVICE

Given the myriad of variable combinations, accurate cost comparison between FTS2000 Compressed Video Transmission Service (CVTS) and dedicated service is extremely difficult. Costs associated with CVTS, change under any of the following conditions:

- any site has Switched Digital Integrated Service (SDIS);
- site location changes;
- number of sites in the conferences changes;
- number of CVTS minutes per month changes;
- duration of each VTC is not exactly one-hour.

Because of the usage-based charges, the cost of three 1-hour VTC sessions is much more than the cost of a single 3-hour session between the same sites. This type of cost dissimilarity precludes most generic observations concerning CVTS versus dedicated lines. About the only generalization available is that CVTS is cost effective for any specific application (combination of sites and usage) that yields site costs less than the comparable cost of maintaining a dedicated VTC connection to a common-user network. The comparison between CVTS and common-user networks must be analyzed on a case by case basis.

C. CONTROL COSTS BY CONTROLLING BANDWIDTH

A straightforward way to reduce VTC costs is to lease only the bandwidth needed to accomplish the VTC. DOD common-user networks support "fractional T-1" lines; FTS2000 also recently started offering "fractional T-1" service. Additionally, the market is migrating toward new pricing schemes related to "dial-up" bandwidth that will support VTC.

For a single dedicated point-to-point T-1 connection, FTS2000 full T-1 and "fractional T-1" service might be less expensive than a common-user network for a specific application. FTS2000 T-1 lines lose their comparative advantage as more sites attempt to connect in a network arrangement. In most cases, the DOD common-user networks will be better able to satisfy the network requirement than trying to build a new network over FTS2000.

If a required VTC link does not exist, the best initial course of action is to contact the common-user network coordinator for the "target VTC community."[39] If the coordinator can accommodate the requirement, the VTC solution will probably occur faster and with less expense than some other strategy.

Defense Information Systems Agency (DISA) is responsible for determining whether long-term connections will best serve

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[39] "Target VTC community" refers to the site or group of sites that will normally be participating in the VTC. As an example, the network coordinator for NAVNET is NCTC Pensacola.

the needs of the Defense Information Systems Network (DISN). Common-user network coordinators and the Defense Commercial Communications Office (DECCO) are also valuable sources for guidance along these lines.

D. IDENTIFYING REQUIREMENTS IS THE KEY

Video teleconferencing (VTC) is maturing to the level where it is no longer extraordinary ("gee, whiz") technology for many DOD applications. This is a significant barrier. While technology is still a novelty, there is a temptation to acquire the newest gadget and then decide how best to employ it.

DOD has been using VTC regularly since the mid-80's when the Defense Commercial Telecommunications Network came on-line with eight different DOD Components in 1986. As the technology becomes more familiar, it is easier to address the issue from the correct perspective; namely to begin by identifying requirements and then deciding how (or if) VTC can satisfy those requirements. Today, some of the DOD requirements supported by VTC include the following:

- operations/mission planning;
- logistics;
- intelligence briefings;
- ad-hoc briefings;
- training;

- telemedicine;

- morale.

After establishing that a VTC requirement exists, there are several useful criteria that can assist in determining the best method for satisfying the requirements.

- Will the requirement support a command and control function? The Warner Amendment stipulates that command and control requirements qualify for exemptions from mandatory FTS2000 use.

- What security level is required by the system? The Joint Worldwide Intelligence Communications System (JWICS) is the only VTC system approved for Sensitive Compartmented Information (SCI). Other security levels might require special arrangements for secure multipoint VTC. Encrypted transmissions might induce additional costs, etc.

- What type of conference is most often required? The five basic categories are as follows: (1) Multi-Point Video Telebroadcast, (2) Multi-Point Video Teleseminar, (3) Point-to-Point Teleconferencing, (4) Selective Presence Multi-point Video Teleconferencing, and (5) Continuous Presence Multi-point Video Teleconferencing.

- Who is the target community (or communities) for the conference? DOD Components are often associated with a common-user network (i.e., the Naval Computer and Telecommunications Command (NCTC) uses NAVNET; the Army might be associated with TNET or SEN, depending on the course of instruction and the required teaching philosophy; etc.)

- How many different sites will be communicating in a single conference? This number can be anywhere from two to several hundred (the latter in the case of a one-way multi-point video telebroadcast training session).

- Is one-way or two-way video required? Two-way video limits the number of VTC participants to 25 sites or less for most conferences.

- What is the expected frequency and duration of the conferences? Occasional VTC use might justify using

FTS2000 that accumulates costs based on actual use. Common-user networks (i.e., DCTN, NAVNET, etc.) typically involve dedicated access where the user pays one fixed fee regardless of the number of conferences.

- Is the VTC requirement recurring (i.e., several weekly meetings) or an infrequent application (i.e., annual/monthly conference)?
- What VTC equipment is already at the conference sites? Locations that already have VTC equipment might simply require some type of transmission access (i.e., terrestrial line or satellite antenna) in order to conduct a VTC.

Answering these types of questions begins to narrow the field of VTC solutions. DISA has established an arrangement with DECCO to provide assistance in any capacity related to the acquisition of VTC equipment or services.

1. Teleseminar Vs. VTC

Teleseminar (one-way video) and VTC (two-way video) services do not (and should not) perform the same function. One-way video methods such as the DCTN-Compressed Digital Video (CDV) provide arguably better quality video because they are transmitting at 3.3 Mbps (vice the 384 Kbps codec speed). After only a few years, the operational cost of video teleseminar is less expensive than the VTC operational cost when five or more sites are involved. Figures 19 and 20 display a comparison between video teleseminar and VTC costs.

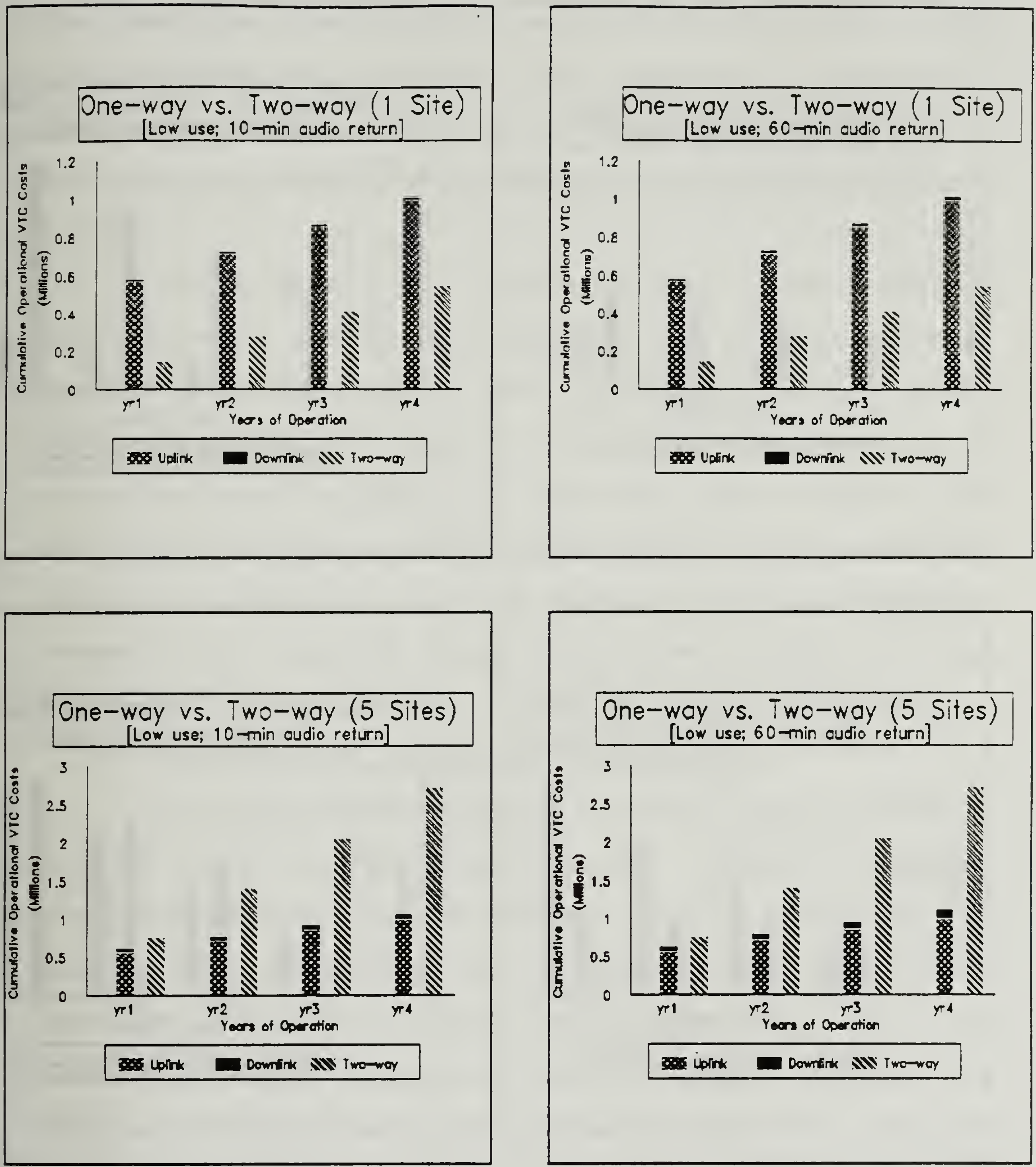

Figure 19 Low Use (1 Hr/day) Teleseminar Vs. VTC Costs[1]

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[1] Long-distance phone (audio return) estimated at $.15/min. Teleseminar costs shown include video equipment at the uplink and monitors at the downlink sites.

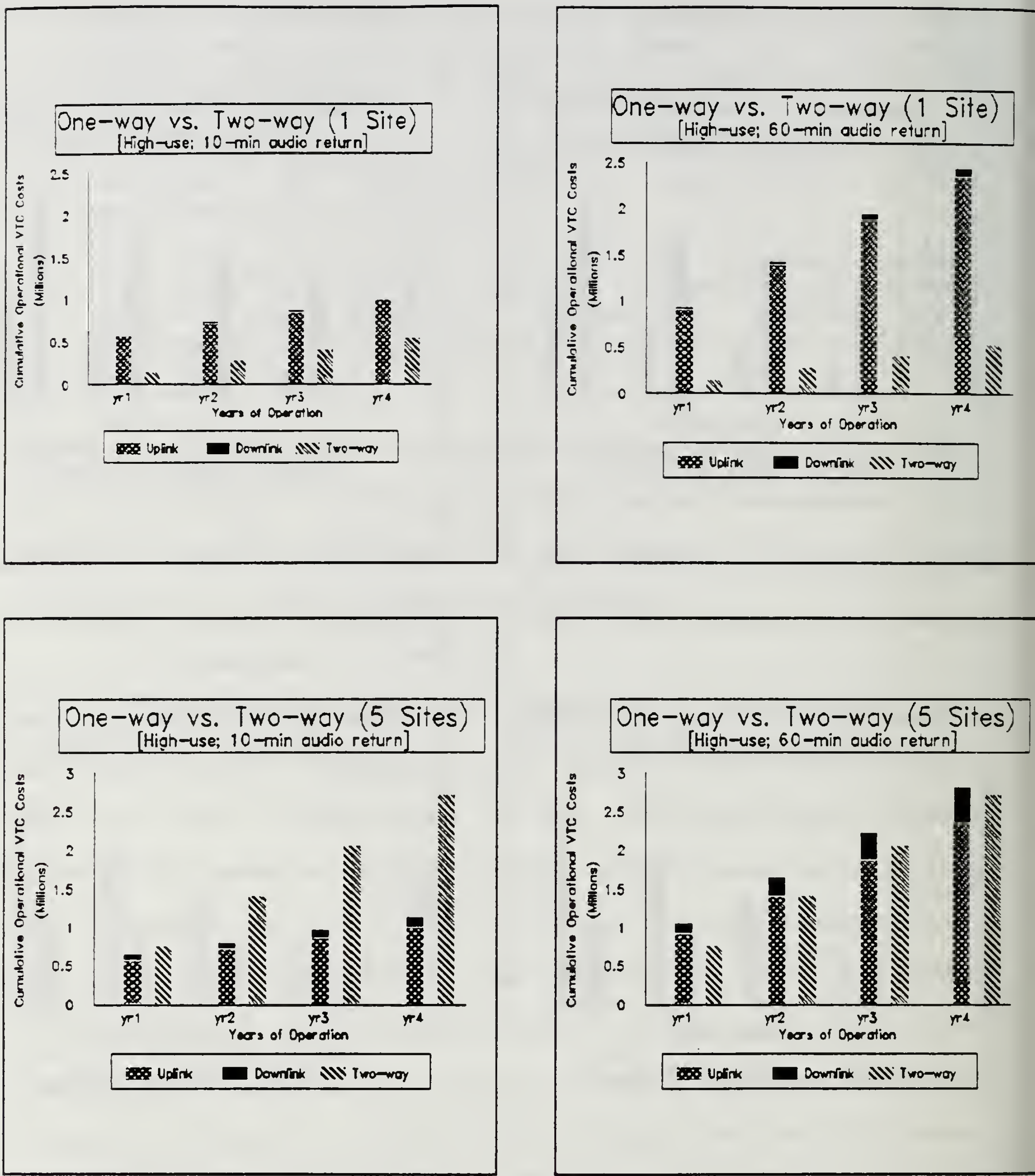

Figure 20 High Use (9 Hrs/day) Teleseminar Vs. VTC Costs[1]

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[1] Long-distance phone (audio return) estimated at $.15/min. Teleseminar costs shown include video equipment at the uplink and monitors at the downlink sites.

Even when the receiving site is connected for audio return throughout the entire session, the teleseminar alternative is less expensive than satellite VTC. Where requirements allow, the lower costs make video teleseminar a preferred alternative to VTC.

It is important to reinforce that one-way video is only "one-way," and is not appropriate for all applications. There is room for video teleseminar and video teleconferencing (VTC) systems within DOD, as long as each system performs a unique role. The simultaneous existence of the Army Training and Education Network (TNET) (two-way training via satellite) and the DCTN-CDV satellite system is reasonable as long as unique requirements exist for the different training methods.

2. Satellite Vs. Terrestrial Transmission

If terrestrial systems are in-place, they are normally more reliable for VTC transmissions. Satellite systems generally provide less reliability due to the effect of weather and atmospherics on the satellite signal. Also, satellite systems still entail higher operational costs than terrestrial links between the same locations. Systems with high-use VTC requirements are generally better off using the dedicated terrestrial service provided by the common-user networks (i.e., DCTN, NAVNET, etc.) Satellite systems are particularly effective when VTC is required in remote

locations, or locations that do not have T-1 lines already in place.

While the teleseminar application can be satisfied by either terrestrial or satellite links, the ubiquity of the satellite broadcast makes it particularly effective for this application.

E. ROLE OF STANDARDS IN VTC IMPLEMENTATION

The acceptance of VTC in DOD has not been without problems. In the haste to satisfy requirements, independent and often incompatible VTC systems materialized within DOD (and also within the private sector). Part of the dilemma was created by the absence of widely accepted VTC standards during the developmental years of the early 80's. It wasn't until 1990 that the ITU-TSS (formerly CCITT) came out with the first version of the umbrella standard (H.320) that currently guides VTC requirements. Even with the formal "acceptance" of the standards, the H.320 recommendations continue to be revised as the technology evolves.

Another factor is that DOD was one of the leading VTC innovators for several parallel, but independent VTC development efforts. Although DOD was helping to establish some of the standards that are in effect today, it was

inevitable that some versions would not contend as the technology matured.[40]

While some are quick to criticize DISA for being slow to adopt mandatory standards, their position has not been an easy one. To accept an inadequate (or incorrect) standard too quickly dooms the organization to obsolescence through poor strategic direction. To indefinitely defer the standards decision is to abdicate direction entirely, leaving chaos. The fine line DISA is choosing has been to withhold specific requirements until industry has had the opportunity to review and provide comments on proposed standards. By promulgating draft standards and delaying mandates, DISA is allowing freedom for commands to procure equipment to meet requirements, while at the same time providing suggestions on the future direction of the technology.

Mandating the H.320 standards provides cohesive near-term direction for VTC applications, but falls short of sounding the death knell for some earlier VTC efforts. However, this is acceptable. Users with non-compliant equipment can continue (in the near-term) to use the equipment to communicate with other similar non-compliant equipment. The specific wording in the ASD-C3I-Policy memorandum requires capabilities to be upgraded "as necessary to comply" with

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[40] The most obvious example is the collection of Compression Labs Inc. Rembrandt I models that are not "standards compliant" but remain in widescale use throughout DOD.

standards. As long as all non-compliant sites are only "required" to communicate with each other, they are in conformance with the policy. All new acquisitions must conform to the mandatory standards.

F. PACIFIC COMMAND EXAMPLE OF VTC INTEROPERABILITY

Commander in Chief, Pacific Command (CINCPAC) was recently diagnosed as having five independent, single-application ("stovepipe") VTC systems.[41] Each system provides limited access to some (but not all) forces and only limited access to commands in the continental United States (CONUS). Figure 21 depicts the five collateral networks. [Ref. 84][42]

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[41] The five systems are (1) PACAF's Numbered Air Forces' (NAF) Net; (2) Navy's Video Information Exchange System (VIXS); (3) DISA's Defense Commercial Telecommunications Network (DCTN); (4) ARPA's Defense Simulation Internet (DSI)/Theater Command and Control System (TCCS); and (5) USFK's Theater Automated Command and Control Information Management System (TACCIMS).

[42] Figures 21 and 22 provide technical concept drawings; they are not engineering drawings.

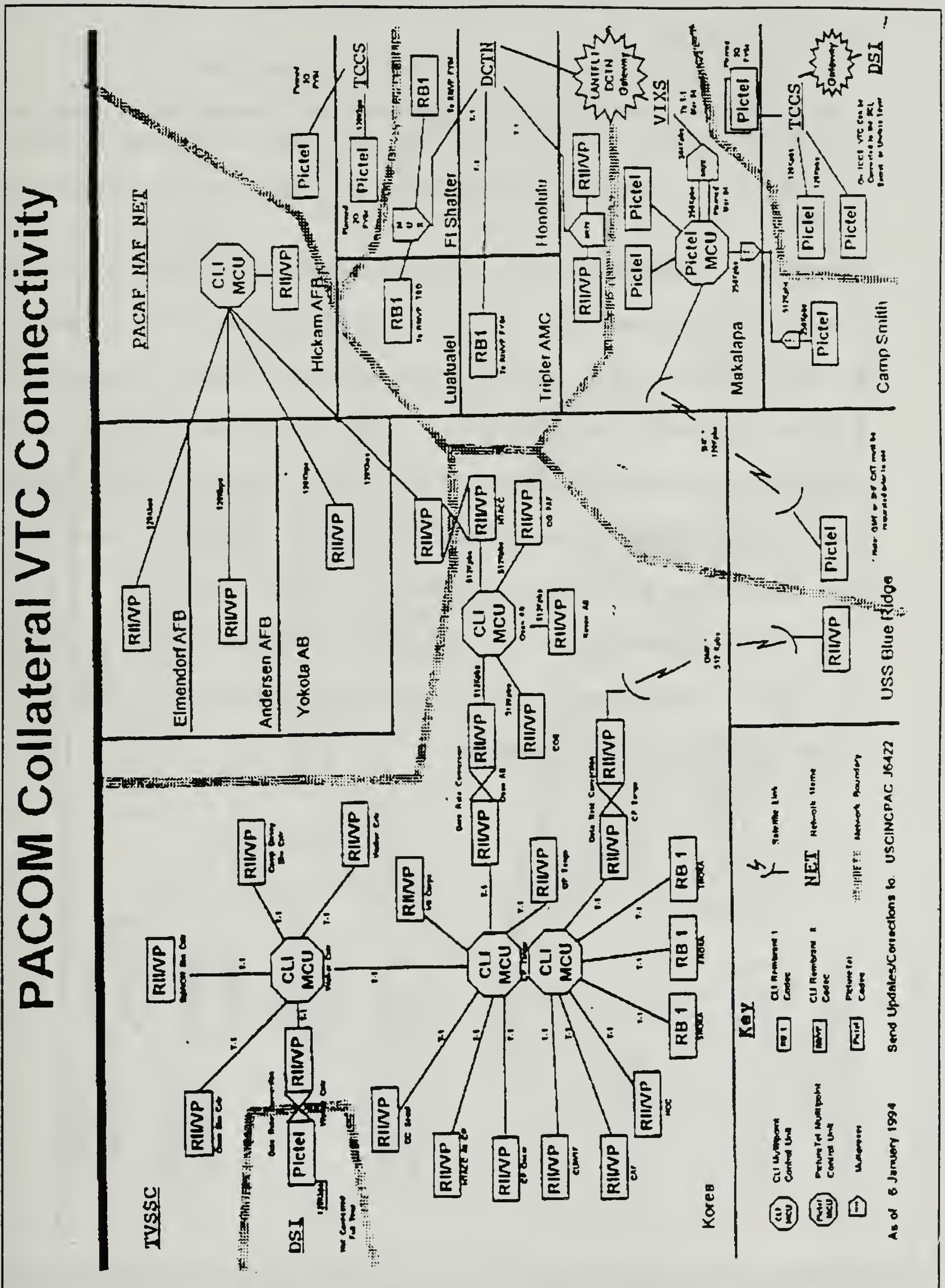

Figure 21 CINCPAC VTC Collateral Systems [Ref. 84]

CINCPAC might have proceeded along either of the following alternatives:

- discard the existing systems and redesign a common system from scratch (or from the largest existing system), or
- wait for DISA to establish a single VTC network for DOD.

Instead, CINCPAC is pursuing a plan to upgrade/interconnect the five systems to form a "cooperative VTC network," that could retain local network management while providing access across network boundaries. The proposed "cooperative VTC network" is described in Figure 22. The estimated conversion cost of $1.3 million is far less than it might cost to rebuild the networks from the ground up. [Ref. 85]

The "cooperative VTC network" is possible because most of the VTC equipment in USCINCPAC conforms to the H.320 interoperability standard.

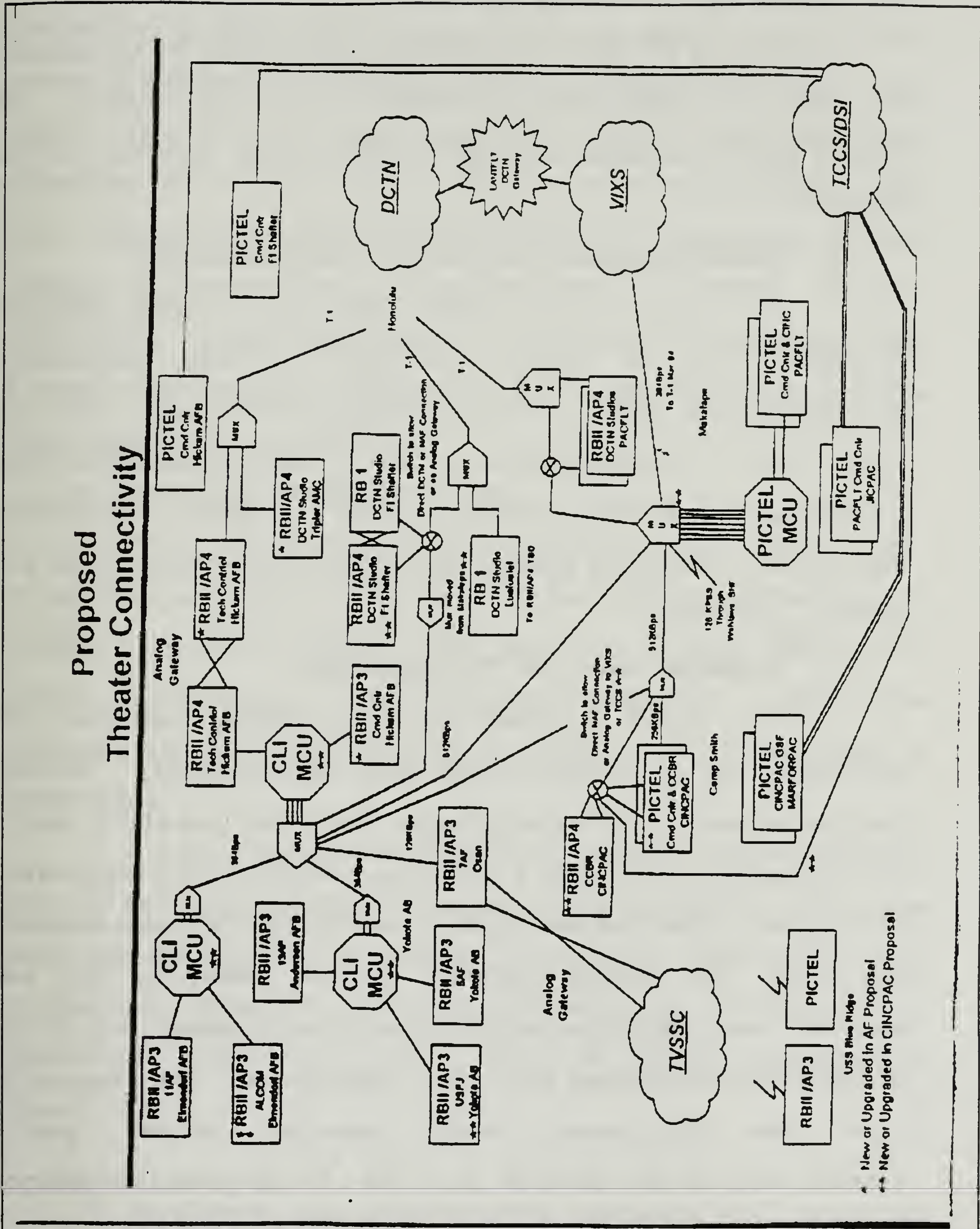

Figure 22 CINCPAC Proposed Cooperative VTC Network [Ref. 84]

G. FUTURE VTC DIRECTION FOR DOD

The future of VTC is changing and DOD must be in position to seize the opportunities brought on by the change. DOD should expect changes in several major areas looming over the horizon.

1. Merging Defense Information Infrastructure

DOD is moving to consolidate all of the disparate networks into a single combined Defense Information Infrastructure (DII). This combined network will not only afford better interoperability, but it should also effectively eliminate the diverse network pricing schemes. Meanwhile, during the transition period, all existing network prices will remain in effect.

2. Enhanced Level of VTC Standards

The H.320 standard is an adequate near-term VTC solution, but it suffers from some deficiencies. Although most equipment in DOD conforms to the H.320 standard (and to the included H.261 codec standard governing video compression techniques), devices are rarely used in the "standards mode." Most DOD VTC occurs between devices made by the same manufacturer, using the manufacturers non-standard (non-H.261) proprietary algorithms for video compression. The reasons are that the proprietary mode provides better quality communications and enables full use of the products designed features.

The implication of widescale "standards mode" avoidance is that the current H.320 standard--the "lowest common denominator" among devices--is inadequate for the long-term. This does not mean that DOD should establish a new "standard." In this era of diminished budget capacity, DOD will find itself less able to "dictate" standards for the market by advancing the technology.[43] DOD's (and in particular, DISA's) responsibility will be to ensure that once a robust standard is identified, it can be embraced with the least amount of discomfort.

3. Shifting Paradigm for VTC

Most DOD VTC applications occur via a reservation-based system wherein conference sites must be scheduled in advance (anywhere between one hour and a year before the actual conference). This process suggests a cumbersome sequence of administrative procedures before conducting a conference.

A more forward-reaching view (and one embraced by the private sector) employs dial-up services to support VTC. This paradigm shift involves moving VTC from a "high-cost, low-convenience network" to a service more along the nature of a phone call [Ref. 2: p. 24]. This is not an unreasonable trend.

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[43] As always, the international community will establish standards, but the future environment can expect less influence from DOD.

Dial-up VTC is not only more convenient, but also more economical. Unless there is an unusually heavy use rate, it is generally more efficient to provide video "on demand" than to tie-up the better portion of a dedicated T-1 line. Initiatives to provide dial-up VTC service are being negotiated in both the DCTN and FTS2000.

4. Desktop VTC

As the codec (video compression device) gets small enough to fit on a single microprocessor chip in a personal computer (PC), the standard VTC use will likewise shift from the high-end VTC room to the desktop. Figure 23 depicts the industry trend for VTC [Ref. 86].

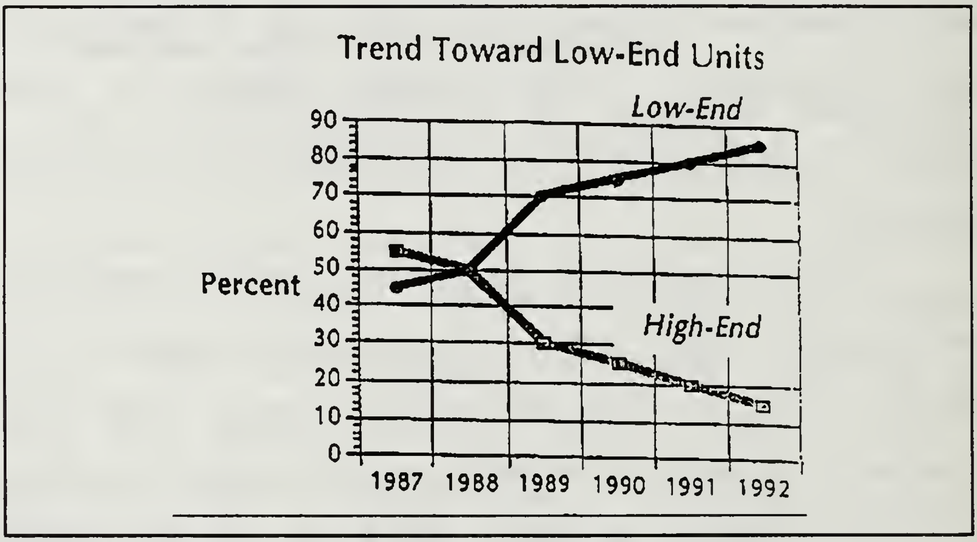


Figure 23 Future VTC Trends [Ref. 86]

Demand for low-end units is being fueled by the shift to desktop VTC. Recall that VTC sales are expected to reach

$3 billion by 1995, with desktop VTC accounting for much of the increase [Ref. 21].

Desktop VTC will not supplant high-end VTC systems in the near-term. Just as high-end VTC resisted popular acceptance until standards were accepted, so will desktop VTC find progress painstaking until the technology matures and common standards are accepted. It will probably be several years before a robust standard is identified that will enable desktop VTC to become as common a utility as the telephone. In the meantime, high-end VTC systems will continue to serve a prominent role in DOD.

APPENDIX A. ABBREVIATIONS

The following is a summary of abbreviations and acronyms used in this paper.

ADPE	Automatic Data Processing Equipment
AFB	Air Force Base
AFIT	Air Force Institute of Technology
AFnet	Air Force Integrated Data Telecommunications Network
ALMC	Army Logistics Management College
ARPA	Advanced Research Projects Agency
ASD-C3I	Office of the Assistant Secretary of Defense-Command, Control, Communications and Intelligence
ATSC	Army Training Support Center
BRI	Basic Rate Interface
CCIR	International Radio Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee (now known as ITU)
CDV	Compressed Digital Video
CESN	CNET Electronic Schoolhouse Network
CIF	Common intermediate format
CINCLANTFLT	Commander-in-Chief, Atlantic Fleet
CLI	Compression Labs Inc.
CNET	Chief of Naval Education and Training
CNO	Chief of Naval Operations
codec	Coder/decoder
CSA	Communication Service Authorization
CSIF	Communications Services Industrial Fund
CVTS	Compressed Video Transmission Service
DACNET	Data Automation Command Network
DCA	Defense Communications Agency (now DISA)
DCTN	Defense Commercial Telecommunications Network
DDN	Defense Data Network
DECCO	Defense Commercial Communications Office (also known as DITPRO)
DES	Digital Encryption Standard
DIA	Defense Intelligence Agency
DISA	Defense Information Systems Agency (formerly DCA)
DISN	Defense Information Systems Network
DITPRO	(DECCO's new name)

DLI	Defense Language Institute
DMP	FTS2000 Dynamic Multipoint CVTS Service
DNCC	DCTN Network Coordination Center
DOD	Department of Defense
DPA	Delegation of Procurement Authority
DS0	64 Kbps single channel pulse code modulation rate
DSCF	Digital Satellite Compression Feature
DSI	Defense Simulation Internet
DSN	Defense Switched Network
DTE	Data terminating equipment
FIPS	Federal Information Processing Standards
fps	Frames per second
GBVS	AT&T Global Business Video Service
GHz	Gigahertz, 1,000,000,000 hertz
HNS	Hughes Network Systems
I/O	Input/output
IMUX	Inverse multiplexer
IRD	Integrated Receiver/Decoder
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector (formerly CCIR)
ITU-T	ITU Telecommunication Sector (formerly CCITT)
JPEG	Joint Photographic Experts Group
JWICS	Joint Worldwide Intelligence Communications System
Kbps	Kilobits (1,000 bits) per second
Mbps	Megabits (1,000,000 bits) per second
MCU	Multi-point control unit
MHz	Megahertz, 1,000,000 hertz
MIL-STD	Military Standard
MOP	Memorandum of Policy
MPEG	Motion Pictures Experts Group
MUX	Multiplexer
NAF	Numbered Air Forces' Network
NAVNET	Navy Common-user Network
NCC	Network Coordination Center
NCTC	Naval Computer and Telecommunication Command
NCTS	Naval Computer and Telecommunication Station
NESEC	Naval Electronic Systems Engineering Center
NIST	National Institute of Standards and Technology
NTSC	National Television Systems Committee

PAL	Phase alteration by line
PBX	Private branch exchange
PC	Personal computer
pel	Picture element
pixel	Picture element
PRI	Primary Rate Interface
QCIF	Quarter common intermediate format
RFP	Request For Proposals
SCI	Sensitive Compartmented Information
SDI	Strategic Defense Initiative
SDIS	Switched Digital Integrated Service
SDP	Service Delivery Points
SECAM	Sequential color and memory; also Systeme electronique couleur avec memoire
SEN	Satellite Education Network
SHF	Superhigh frequency (between 3,000 and 30,000 megahertz)
SOC	Service Oversight Center
TACCIMS	Theater Automated Command and Control Information Management System
TCCS	Theater Command and Control System
TDMA	Time division multiple access
TNET	Army Video Teletraining Network
TRADOC	Army Training and Doctrine Command
USFK	U.S. Forces Korea
VIP	Very important person
VIXS	Video Information Exchange System
VSAT	Very small aperture terminal
VTC	Video Teleconferencing
VTel	Video Telecom
VTU	Video Teleconferencing Unit

APPENDIX B. VIDEO TRANSMISSION OVERVIEW

There are four fundamental factors involved with transmitting moving video:

- luminance -- the distribution of light and shade,
- perception of depth,
- perception of motion based on luminance and depth, and
- perception of color (hues and tints). [Ref. 18: p. 866]

Video systems convert these factors into electrical impulses for transmission. Moving video is reproduced by transmitting a single picture (or frame) at a time. Each frame is divided into discrete squares called picture elements or pixels (also pels).

Electrical signals that represent the picture are obtained by "scanning" the frame, pixel by pixel, from left to right starting with the first row and assigning a voltage and current variation to the luminance value of each pixel. When the last pixel in the row is finished, the scanner moves to the leftmost element in the next row. The process continues until all pixels in the frame have been scanned. The following figure depicts the scanning process.

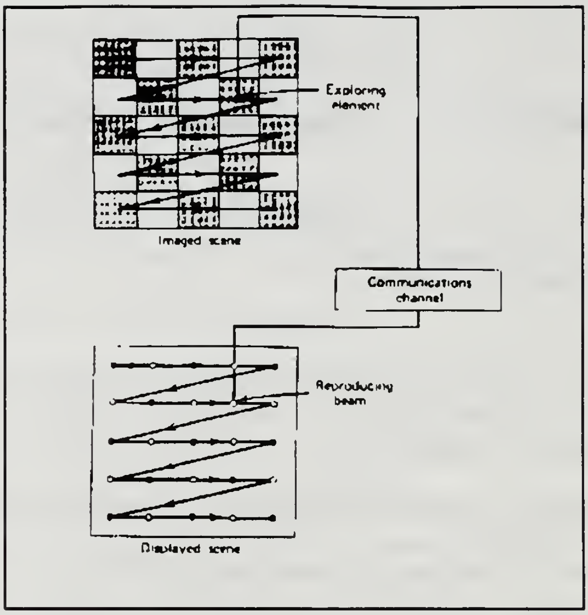


Figure 24 Scanning Process for Transmitting Video Pictures [Freeman, p.867]

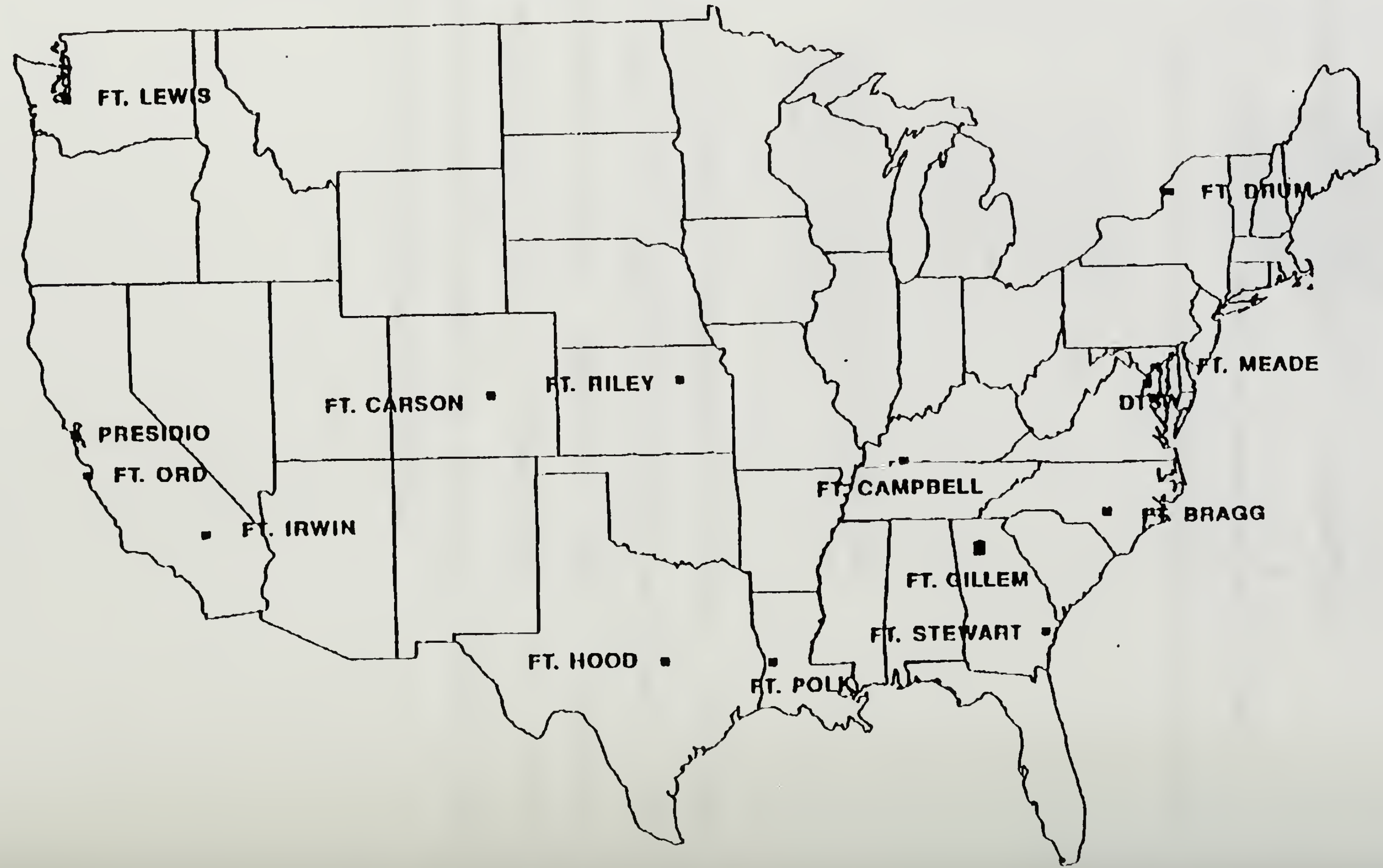
In order to provide the sensation of motion, individual pictures (or frames) are transmitted in rapid succession. The National Television Systems Committee (NTSC) requires a 30 frame per second rate for full-motion video. The quality of a Super-VHS tape is 28 frames per second; a standard VHS tape is approximately 26 frames per second.

APPENDIX C. DCTN VTC USER LOCATIONS

The following pages provide diagrams of DCTN VTC locations through the continental United States (CONUS).

DCTN

U.S. ARMY FORCES COMMAND VTC LOCATIONS



06/22/92

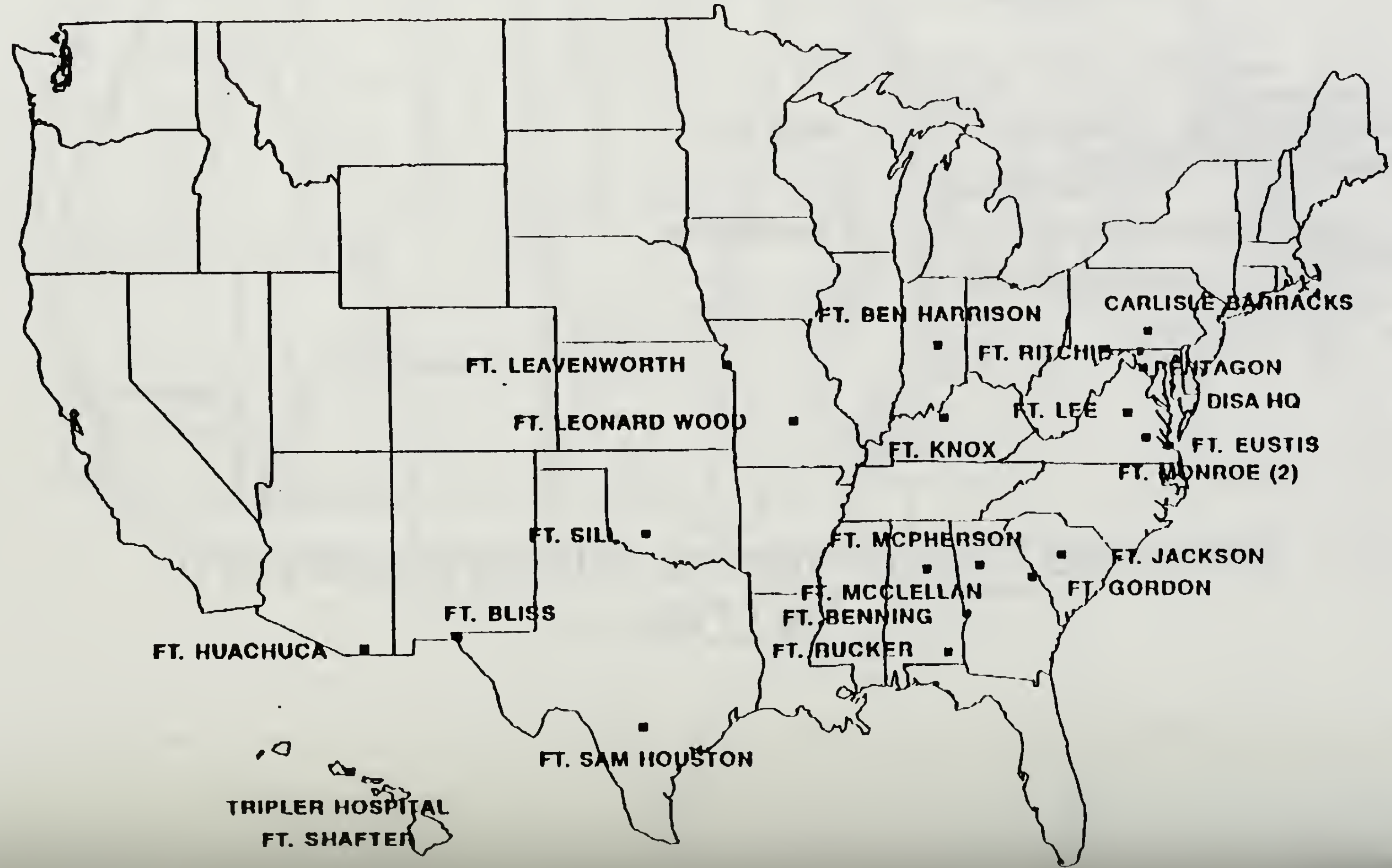
DCTN

U.S. ARMY MATERIEL COMMAND VTC LOCATIONS

08/23/91

DCTN

HQ DEPT. ARMY / TRADOC VTC LOCATIONS



08/04/93

DCTN

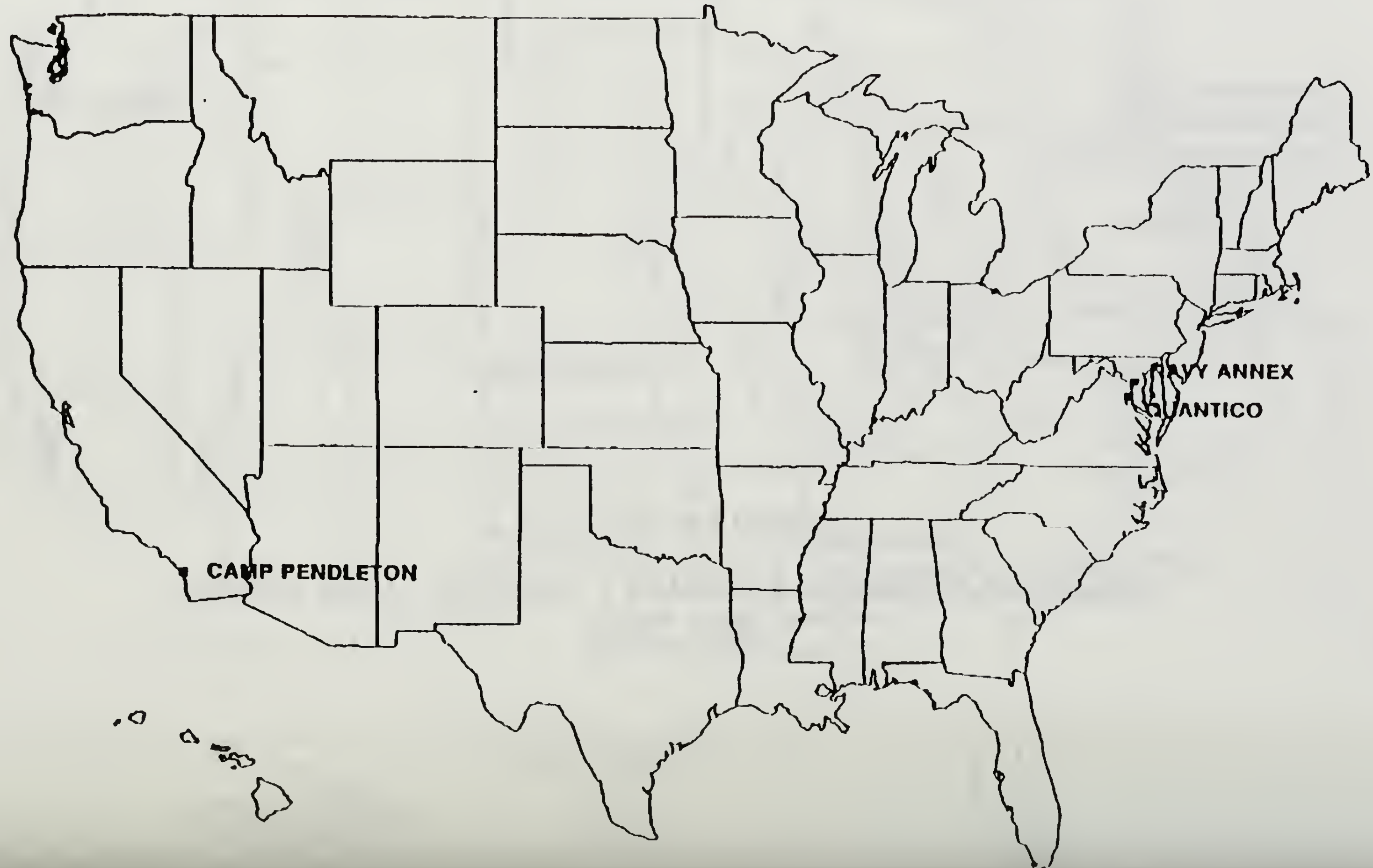
ARMY NAT. GUARD / MTMC / SURGEON GEN.

VTC LOCATIONS

12/17/93

DCTN

U.S. MARINE CORPS VTC LOCATIONS



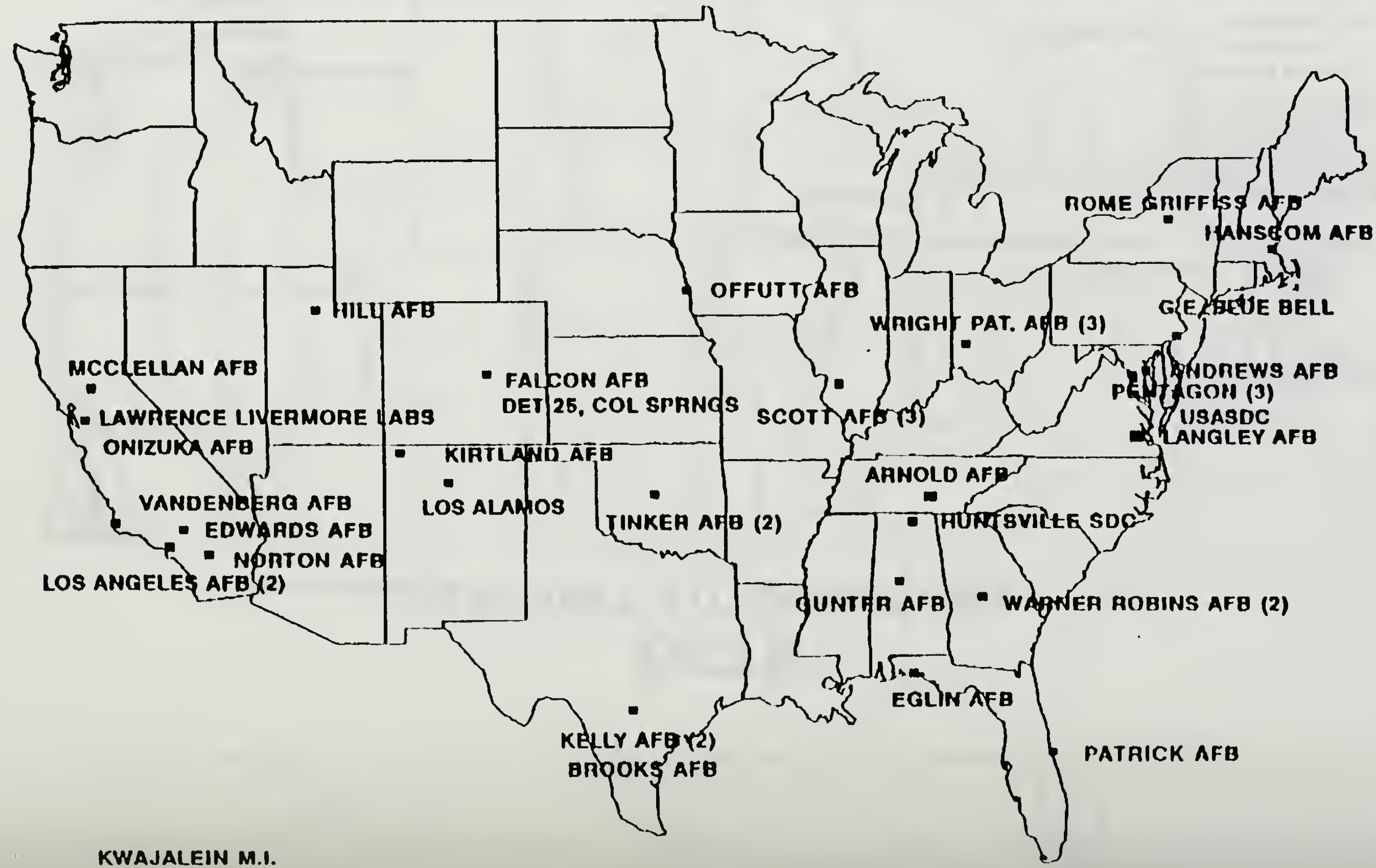
DCTN

U.S. NAVY VTC LOCATIONS

12/17/93

DCTN

U.S. AIR FORCE / BMDO VTC LOCATIONS



12/17/93

APPENDIX D. TNET STANDARD EQUIPMENT SUITE

The following equipment is provided to each TNET instructing site:

1. Top Bill, BK235, Composite Video . . . . . 1 ea
2. MediaMax 386 media conferencing unit . . . 1 ea
3. PIP kit, Internal, NTSC (Picture-in-Picture) 1 ea
4. Kit, Gated audio mixer, BiAmp, 120V . . . . 1 ea
5. Cable, XLR-Plug to XLR-Jack, 50′ . . . . . . 16 ea
6. Microphone, Lavaliere condenser . . . . . . 1 ea
7. Microphone cable, XLR, 50′ . . . . 4 ea
8. Crown Mic 170SW . . . . 10 ea
9. EV308 Elmo Document Camera . . . . 1 ea
10. Pen Pal Control Tablet . . . . 1 ea
11. 35" Mitsubishi Monitor . . . . 2 ea
12. Computer Keyboard . . . . 1 ea
13. Smart Camera and Controller . . . . 1 ea
14. Remote Control . . . . 1 ea
15. MediaMax software and documentation . . . . 1 set
16. Surge protector . . . . 1 ea
17. RS-449 Loopback plugs . . . . 2 ea
18. Cable, 10′phone . . . . 1 ea
19. Cable, keyboard extension . . . . 1 ea
20. Video cable BNC-BNC . . . . 1 ea
21. RGB adapter cable . . . . 1 ea
22. Computer conference cable . . . . 1 ea
23. Attenuation box . . . . 1 ea
24. STR-101 cable . . . . 2 ea
25. STR-102 cable . . . . 2 ea

Each Remote (Student) site receives the following Network equipment:

1. Outdoor Unit . . . . 1 ea
2. Indoor Unit . . . . 1 ea
3. Indoor Unit Controller . . . . 1 ea
4. Installation Kit . . . . 1 ea
5. ITC Remote Software disk . . . . 1 ea
6. 2.4 meter Antenna . . . . 1 ea

[Ref. 87]

APPENDIX E. FTS2000 CVTS ROOMS

The following agencies and sub-agencies have Compressed Video Transmission Service (CVTS) video teleconferencing on FTS2000:

Tennessee Valley Authority **(TVA)**

U.S. Department of Defense
- Army Corps of Engineers **(COE)**

U.S. Department of Commerce
- National Institute of Standards and Technology **(NIST)**

U.S. Department of Energy **(DOE)**
- Bonneville Power Administration
- Brookhaven National Labs
- Chicago Operations Office
- Hanford Site
- Los Alamos National Laboratory
- Martin Marietta Energy Systems
- Operations Office
- RMI - Decommissioning Project
- Savannah river Site
- TRW

U.S. Department of Interior **(DOI)**
- Bureau of Indian Affairs
- Bureau of Reclamation
- Office of the Secretary
- Minerals Management Service

U.S. Department of Transportation **(DOT)**

U.S. Department of the Environmental Protection Agency **(EPA)**

U.S. Department of Health and Human Services **(HHS)**

U.S. Department of Agriculture **(DOA)**
- Forest Service
- Office of Finance and Management
- Office of Information Resource Management
- Soil Conservation

The following is an alphabetical listing by state of FTS2000 CVTS rooms (rooms not available to other agencies are indicated by "*"):[44]

STATE	CITY	# OF ROOMS	AGENCY
ALABAMA	Huntsville		COE
CALIFORNIA	Irvine		DOE
	Oakland		*DOE
	Redding		DOI
	Sacramento		DOI
	San Francisco		COE
			EPA
			*USDA
	Shasta Lake		DOI
	Livermore		*DOE
COLORADO	Boulder		NIST
	Denver		EPA
	Fort Collins		USDA
	Golden		DOE
	Grand Junction		DOE
	Lakewood	2	DOI
DELAWARE	New Castle		*SSA
	Wilmington		SSA
DISTRICT OF COLUMBIA	Washington		COE
		2	DOE
			DOI
			DOT
		3	EPA
			*SSA
			USDA
FLORIDA	Jacksonville		COE
GEORGIA	Atlanta		COE
			EPA
	Savannah		COE

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[44] Room listing obtained from the "Network A Video Room Guide," published by the Office of FTS2000 General Services Administration Service Oversight Center, Network "A."

IDAHO	Boise		DOI
	Idaho Falls		DOE
ILLINOIS	Argonne	2	DOE
	Champaign		COE
	Chicago		EPA
KANSAS	Kansas City		EPA
KENTUCKY	Paducah		*DOE
LOUISIANA	New Orleans	2	USDA
MARYLAND	Aberdeen Proving Grounds		COE
	Baltimore	2	SSA
			*NIH
	Bethesda	6	NIH
	Gaithersberg		*NIST
	Germantown	2	DOE
MASSACHUSETTS	Boston		EPA
	Cambridge		DOT
	Waltham		COE
MICHIGAN	Bay City		EPA
MISSISSIPPI	Vicksburgh		COE
MISSOURI	Kansas City		USDA
	Saint Louis		COE
MONTANA	Billings		DOI
NEBRASKA	Lincoln		USDA
	Omaha		COE
NEVADA	Boulder City		DOI
	Las Vegas	2	DOE
NEW HAMPSHIRE	Hanover		COE
NEW JERSEY	Edison		EPA
NEW MEXICO	Albuquerque		*DOE
			DOI
			USDA
	Los Alamos		DOE
NEW YORK	New York		COE
			EPA

	Upton		*SSA DOE
NORTH CAROLINA	Research Triangle Park		EPA
NORTH DAKOTA	Dickenson		USDA
OHIO	Ashtabula		DOE
	Cincinnati		COE EPA
	Miamisburg		DOE
	Piketon		*DOE
OKLAHOMA	Oklahoma City		
OREGON	Portland		
PENNSYLVANIA	Philadelphia		EPA
	Pittsburgh		DOE
SOUTH CAROLINA	Aiken		DOE
TENNESSEE	Chattanooga		TVA
	Oak Ridge		*DOE
TEXAS	Dallas		EPA
	Fort Worth		USDA
UTAH	Salt Lake City		DOI
VIRGINIA	Falls Church		*SSA
	fort Belvoir		COE
	Rosslyn		USDA
	Dunn Loring		*DOE
WASHINGTON	Lacey		DOE
	Richland	2	DOE
	Seattle		EPA
	Spokane		DOE
	Vancouver		DOE
	Walla Walla		DOE
WEST VIRGINIA	Morgantown		*DOE

LIST OF REFERENCES

1. _____, "Industry News," *Teleconferencing News*, p. 9, July/August 1993.

2. Bass, Brad, "Feds Slow to Buy Videoconferencing Systems," *Federal Computer Week*, 6 October 1993.

3. Defense Information Systems Agency Draft Military Standard MIL-STD-188-331 (draft), *Interoperability and Performance Standard For Video Teleconferencing*, 10 November 1993.

4. Schaphorst, Richard, notes presented at TELECON XIII, San Jose, California, 10 November 1993.

5. GPT Video Systems, "Take a Better Look at H.320," product brochure by GPT Video Systems, provided February 1994.

6. Jolly, Martin E., *Video Teleconferencing Feasibility Study at The Naval Postgraduate School*, Master's Thesis, Naval Postgraduate School, Monterey, California, p. 6, June 1992.

7. Portway, Patrick S., "The Growth of Videoconferencing," *Technical Guide to Teleconferencing & Distance Learning*, p. 2, Applied Business teleCommunications, 1992.

8. Andriole, Stephen J., "Teleconferencing Advances," *Signal*, p. 17, December 1983.

9. Brooksby, Merrill R., "Videoconferencing--Two Way Interactive Video," in *Technical Guide to Teleconferencing & Distance Learning*, edited by P.S. Portway and C. Lane, pp. 61-62, Applied Business teleCommunications, 1992.

10. Boyd, Colin, "To Compress or Not to Compress?--That is the Question," in *Technical Guide to Teleconferencing & Distance Learning*, edited by P.S. Portway and C. Lane, p. 52, Applied Business teleCommunications, 1992.

11. Ang, Peng H., Peter A. Ruetz, and David Auld, "Video Compression Makes Big Gains," *IEEE Spectrum*, p. 16, October 1991.

12. *1993-1994 Teleconferencing Resources Directory*, p. 12, Knowledge Industry Publications, Inc., 1994.

13. Telephone conversation between Charles King, MITRE, and LCDR Michael Nerino, 27 January 1994.

14. U.S. Distance Learning Association, "What is Teleconferencing?," p. 15, October 1991 information distributed at TELECON XIII, San Jose, California, 9 November 1993.

15. MITRE, *Video Teleconferencing Standards, An Overview*, by Charles King, 3 January 1994.

16. Jurgen, Ronald K., "An Abundance of Video Formats," *IEEE Spectrum*, p. 27, March 1992.

17. Lakin, James D., "CLI Compressed Digital Video Broadcast System," in *Technical Guide to Teleconferencing & Distance Learning*, edited by P.S. Portway and C. Lane, p. 59, Applied Business teleCommunications, 1992.

18. Freeman, Roger L., *Telecommunication Transmission Handbook*, 3rd ed., John Wiley & Sons, Inc., 1991.

19. _____, "CATS: The Drive for Audiographics Standards," *TeleCons*, p. 7, 10 November 1993.

20. Schaphorst, Richard A., "Standards Related To Audiovisual Communications," in *Technical Guide to Teleconferencing & Distance Learning*, edited by P.S. Portway and C. Lane, p. 105, Applied Business teleCommunications, 1992.

21. Francis, Bob, "Tune in To Cheaper Videoconferencing," *Datamation*, p. 48, 1 October 1993.

22. Portway, Patrick S., "Orientation," in *Technical Guide to Teleconferencing & Distance Learning*, p. 4, Applied Business teleCommunications, 1992.

23. Kelly, Clinton W., "Video Teleconferencing For Crisis Applications," *Signal*, p. 28, July 1982.

24. Magnant, Robert S., "Health Care Telecommunication," *Signal*, p. 32, January 1982.

25. Grossman, Larry, "Face to Face," *Government Executive*, June 1991.

26. Welles, Alison, D. "Teaching the Troops: the U.S. Army has Taken Training to the Airwaves," p. 12, *Teleconference*, 1991.

27. Telephone conversation between Art Wolf, NCTC Pensacola, and LCDR Michael Nerino, 17 February 1994.

28. Compression Labs Incorporated., Rembrandt II/VP product description, p. 2, Compression Labs, Inc., 1993.

29. Department of Defense UNCLASSIFIED Directive 4640.11 to all Department of Defense Components, Subject: Mandatory Use of Military Telecommunications Standards in the MIL-STD-188 Series, 21 December 1987.

30. Department of Defense UNCLASSIFIED Directive 4640.13 to all Department of Defense Components, Subject: Management of Base and Long-Haul Telecommunications Equipment and Services, 5 December 1991.

31. Department of Defense UNCLASSIFIED Directive 4640.14 to all Department of Defense Components, Subject: Base and Long-Haul Telecommunications Equipment and Services, 6 December 1991.

32. Defense Communications Agency, *Defense Switched Network Program Plan: FY 1992-1997*, April 1991.

33. Telephone conversation between Bruce Jarvis, DECCO, and LCDR Michael Nerino, 25 January 1994.

34. _____, "Video Teleconferencing: Industry Alliance," *EDGE, On & About AT&T*, p. 35, AT&T, 15 November 1993.

35. Department of Defense ASD-C3I Policy Memorandum, Subject: Department of Defense (DOD) Policy for Videoteleconferencing (VTC) Management, Acquisition, and Standards, 26 October 1993.

36. Hughes Network Systems, "inTELEconference" product information brochure, DSG111-101D, included as part of the Army TNET information package, January 1994.

37. "Video Information Exchange System (VIXS) - Concept of Operations (Draft)," prepared by Naval Electronic Systems Engineering Center (NESEC), Charleston, South Carolina, 30 August 1993.

38. Marsan, Carolyn D., "AFnet Serves as Launch Pad for DISN," *Federal Computer Week*, p. D20, 26 July 1993.

39. Masud, S.A., "AF Gets Serious about ISDN; 100 Muxes Will Support Classified Network with Voice, Video, Fax," *Government Computer News*, pp. 57-58, 30 August 1993.

40. USCINCPAC (J6422), "VTC Connectivity," figure describing Pacific Command Numbered Air Forces Network, provided by USCINCPAC (J6422), February 1994.

41. Defense Intelligence Agency, *Intelligence Planners Communications Handbook*, UNCLASSIFIED portion only, BDM International, Inc., 1991.

42. Gold, Elliot M., "Industry-wide Video Networks Thrive," *Networking Management*, November 1991.

43. AT&T, "Command and Control That Stands the Test of Time," Special Edition of *Government Issue*, AT&T's Newsletter for its Federal Government Customers, Edited by Regina Esposito (circa July, 1993).

44. UNCLASSIFIED electronic mail from MAJ Monica Gorzelnik, DISA, to LCDR Michael Nerino, 17 February 1994.

45. AT&T, "Welcome," package provided for tours of the DCTN Network Control Center (DNCC) Dranesville, Virginia, p. B1465.67-2, AT&T, 1993.

46. Telephone conversation between Renard Alexander, AT&T, and LCDR Michael Nerino, 1 March 1994.

47. Hamblen, Diane, "Video Teleconferencing, The Next Best Thing to Being There," *CHIPS*, p. 8, July 1993.

48. Telephone conversation between Dan Kugler, AT&T, and LCDR Michael Nerino, 4 February 1994.

49. AT&T, "DCTN Features and Functions," AT&T product information brochure provided February 1994.

50. Telephone conversation between Renard Alexander, AT&T, and LCDR Michael Nerino, 8 February 1994.

51. Defense Commercial Communications Organization (DECCO) Communication Service Authorization between DECCO and AT&T, 18 November 1993.

52. Naval Telecommunications Command (NAVTCO), "NAVNET Point Paper," provided by NAVTCO circa 15 October 1992.

53. Telephone conversation between Art Wolf, NCTC Pensacola, and LCDR Michael Nerino, 14 February 1994.

54. Naval Computer and Telecommunications Station (NCTS) Pensacola, UNCLASSIFIED facsimile, "1993 NAVNET Backbone," 14 February 1994.

55. Hughes Communications, "Galaxy Satellite System Summary," information brochure by Hughes Communications, August 1993.

56. Telephone conversation between Ron Shriner, U.S. Army Training Support Center (ATSC-TNET), and LCDR Michael Nerino, 13 January 1994.

57. Frantz, Audra, "AT&T Launches Telstar 401," *TeleCons*, p. 1, January 1994.

58. Defense Intelligence Agency, *Intelligence Planners Communications Handbook*, UNCLASSIFIED portion only, p. 6-22, BDM International, Inc., 1990.

59. Miralite Communications, *Specification Guide for Buying Downlink Satellite Earth Stations For Distance Learning Applications*, p. 5., circa 1993.

60. Holden, Jolly, "Creating A Satellite Based Distance Learning Network Using Compressed Digital Video (CDV)," presentation notes, February 1994.

61. Telephone conversation between Dr. Jolly Holden, AT&T, and LCDR Michael Nerino, 14 February 1994.

62. AT&T, "DCTN Compressed Digital Video Service," AT&T product information, AT&T Sheet Nr. 123192, p. 1, circa 1993.

63. Telephone conversation between Dr. Jolly Holden, AT&T, and LCDR Michael Nerino, 8 February, 1994.

64. FCC Tariff No. 16., pp. 117.6-117.10, effective 15 September 1993.

65. Army Training and Doctrine Command (TRADOC), "Video Teletraining Over TNET and SEN," information brochure provided January 1994.

66. _____, "Video Take Top Honors at Telecon XII," *Teleconference*, p. 23, November/December 1992.

67. Hughes Network Systems. "inTELEconference," product information brochure, circa 1993.

68. Army Training and Doctrine Command (TRADOC), "TNET...Something Smart in The Air," information brochure, p. 1., provided 1994.

69. Masud, Steven A., "Conference Previews FTS 2010 Telecom Odyssey," *Government Computer News*, p. 34, January 10 1994.

70. Naval Electronic Systems Engineering Center, Portsmouth, "C4I Technology Advances in Exercise Ocean Venture '93," video produced by EL Hamm & Associates, 1993.

71. Bullock, Harold E., and others, "C4I2 In Space: Solving The Satcom Shortfall," p. 12-12, 1 April 1991.

72. Telephone conversation between LCDR Baciocco, Pentagon (N61), and LCDR Michael Nerino, 15 February 1994.

73. Telephone conservation between Gary Haddox, GSA, and LCDR Michael Nerino, 25 January 1994.

74. Telephone conservation between Darlene Dean, GSA, and LCDR Michael Nerino, 25 January 1994.

75. _____, "Users Rate Long-Distance Carriers: FTS2000: A Mixed Blessing," *Data Communications*, p. 92, August 1993.

76. Masud, S.A., "Scott--'Mr. FTS 2000'--Retires with Final Shot at Mandatory Use," *Government Computer News*, p. 3., 10 January 1994.

77. Telephone conversation between Gary Haddox, GSA, and LCDR Michael Nerino, 8 February 1994.

78. AT&T. "AT&T FTS2000 Integrated Custom Network Compressed Video Transmission Service," AT&T product information brochure provided February 1994.

79. Telephone conversation between Tanya Brown, AT&T, and LCDR Michael Nerino, 3 March 1994.

80. Telephone conversation between John Hanley, GSA, and LCDR Michael Nerino, 16 February 1994.

81. Telephone conversation between Darlene Dean, GSA and LCDR Michael Nerino, 16 February 1994.

82. Sprint. "FTS2000 Compressed Video Teleconferencing Service CVTS)," Sprint information brochure dated 20 March 1991.

83. Sprint, UNCLASSIFIED facsimile from Sprint Video Group, entitled "Sprint Meeting Channel Service Rates," 14 January 1994.

84. USCINCPAC (J6422), UNCLASSIFIED information paper on "USPACOM Video Teleconferencing (VTC) Interoperability," 8 February 1994.

85. USCINCPAC (J6422), UNCLASSIFIED information paper on "USPACOM Video Teleconferencing (VTC) Interoperability," 8 February 1994.

86. "Videoconferencing: Directions for Group and Desktop Systems," slide by the Yankee Group included in a presentation by Mark Lowenstein at TeleCon XIII, San Jose, California, November 1993.

87. UNCLASSIFIED Facsimile Memorandum from Ron Shriner, U.S. Army Training Support Center, to LCDR Michael Nerino, 2 February 1994.

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